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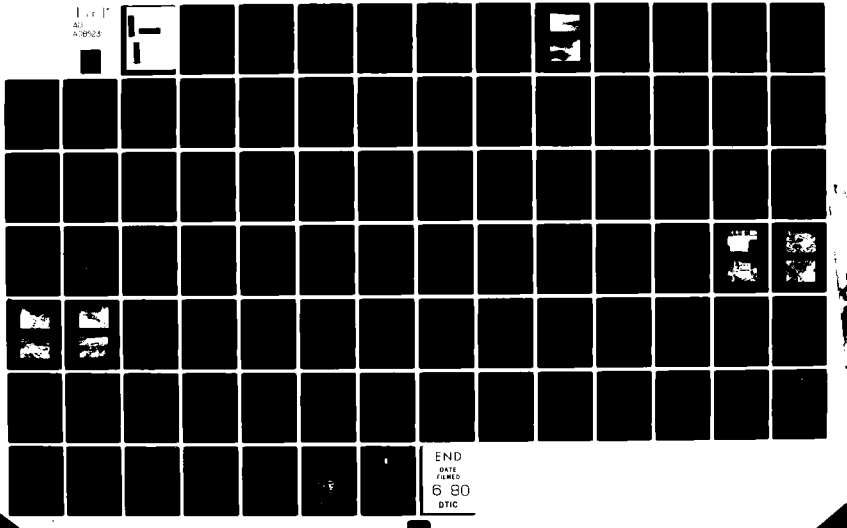

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OHIO RIVER BASIN

KENDA DAM
WESTMORELAND COUNTY, ~~COMMONWEALTH OF PENNSYLVANIA~~
(NDI ~~No.~~ PA 00459, PennDER ~~No.~~ 65-118)

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared for: DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

Prepared by: MICHAEL BAKER, JR., INC.
Consulting Engineers
4301 Dutch Ridge Road
Beaver, Pennsylvania 15009

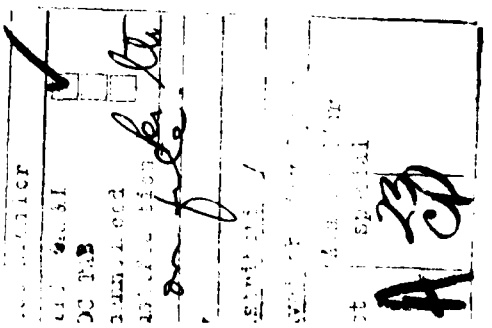
PREFACE

This report is prepared under guidance contained in the "Recommended Guidelines for Safety Inspection of Dams," for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I Inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.



PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Kenda Dam, Westmoreland County, Pennsylvania
NDI No. PA 00459, PennDER No. 65-118
Tributary of Little Sewickley Creek
Inspected 14 December 1979

ASSESSMENT OF GENERAL CONDITIONS

Kenda Dam is owned and operated by the Westmoreland Recreation Society, Inc. and is classified as a "Small" size - "High" hazard dam. The dam was found to be in poor overall condition at the time of inspection.

Hydraulic/hydrologic evaluations, performed in accordance with procedures established by the Baltimore District, Corps of Engineers, for Phase I Inspection Reports, revealed that the spillway will not pass the 1/2 Probable Maximum Flood (1/2 PMF) without overtopping the dam. A spillway design flood (SDF) in the range of the 1/2 PMF to Probable Maximum Flood (PMF) is required for Kenda Dam. The 1/2 PMF was selected as the SDF because of the small size of the drainage area and impoundment. During the 1/2 PMF, the dam is overtopped by a maximum depth of 1.24 feet for a total duration of 7.00 hours. It is estimated that, in its present condition, the dam is likely to fail during the 1/2 PMF. Analysis performed to assess the impact of failure of the dam on the damage center downstream indicated that a significant increase in damage would occur compared to conditions if the dam did not fail. Therefore, the spillway is assessed as being "seriously inadequate". It is recommended that the owner immediately initiate an engineering study to further evaluate the spillway capacity and develop recommendations for remedial measures to reduce the overtopping potential of the dam.

In summary, Kenda Dam is classified as being in an "Unsafe" - "Non-Emergency" condition.

Several items of remedial work should be performed by the owner without delay. Items 1 through 9 below should be completed under the direction of a qualified professional engineer experienced in the design and construction of earth dams and appurtenant structures. These include:

1) The owner should immediately initiate an engineering study to further evaluate the spillway capacity and develop recommendations for remedial measures to reduce the overtopping potential of the dam.

2) The owner should initiate an engineering study to provide a quantitative assessment of the dam stability and develop recommendations for remedial action as necessary. Material property investigations, piezometers, and seepage analysis should be an integral part of this study.

3) The location, condition, and operability of the outlet works should be determined. If the current outlet works cannot be used for drawdown of the reservoir, then the outlet works should be rehabilitated or an alternate drawdown system developed.

4) The trees on the downstream slope of the dam should be removed. Prior to the removal of these trees, however, the owner should initiate an engineering study concerning the potential problems associated with their removal. This study should result in recommendations as to the best method of removal that would produce minimal damage to the embankment while eliminating the possibility of voids in the embankment forming as a result of a decaying root system.

5) As a part of the aforementioned studies, the "as built" condition of the dam should be determined and recorded on engineering drawings for future reference.

6) The erosion and undercutting of the toe of the embankment should be repaired and appropriate measures taken to prevent any future undercutting/ erosion.

7) The erosion gullies on the downstream face of the dam should be repaired. Proper erosion control measures, i.e., vegetative cover, should be placed on the downstream slope to minimize erosion.

8) It is recommended that the dam be raised at a minimum to Elevation 1025.5 feet Mean Sea Level (M.S.L.) (top of spillway training walls).

9) The undermining of the end of the discharge apron should be repaired and measures taken to prevent future undermining.

10) The debris at the crest of the spillway and at the inlets of the corrugated metal pipes in the crest should be removed and efforts made in the future to remove this debris as it accumulates.

11) The debris which has collected in the discharge channel of the spillway should be removed. This includes the debris at the end of the discharge apron, the debris which has been dumped into the discharge channel from the embankment crest, and the timbers which have fallen from the embankment crest into the channel.

In addition, the following operational measures are recommended to be undertaken by the owner:

1) Develop a detailed emergency operation and warning system.

2) During periods of unusually heavy rain, provide around-the-clock surveillance of the dam.

3) When warning of a storm of major proportions is given by the National Weather Service, the owner should activate the emergency operation and warning system.

It is further recommended that formal inspection, maintenance, and operation procedures and records be developed and implemented.

Submitted by:

MICHAEL BAKER, JR., INC.

John A. Dziubek, P.E.
Engineering Manager-Geotechnical

Date: 8 May 1980

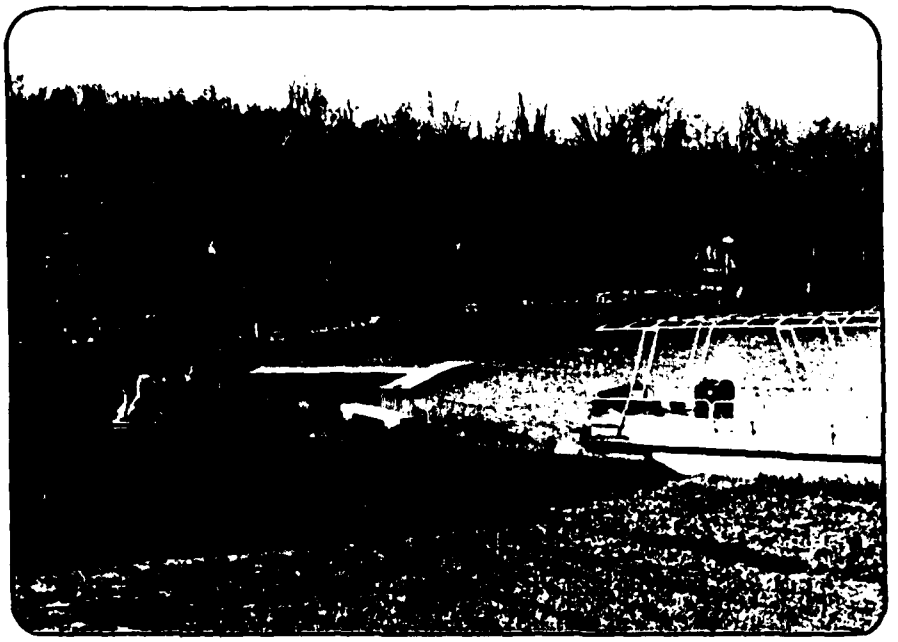
Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

Date: 28 May 1980

KENDA DAM



View of Upstream Side of Dam from the Left Abutment

View of Upstream Side of Dam from the Right Abutment

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
KENDA DAM
NDI No. 00459, PennDER No. 65-118

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority - The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose of Inspection - The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances - Kenda Dam is an earthfill embankment with a height of 18.8 feet and a total crest length of 450 feet. The embankment has a minimum crest width of 10 feet with a side slope of 1.5H:1V (Horizontal to Vertical) on the upstream face and side slopes on the downstream face ranging from 1H:1V to 1.5H:1V.

The spillway, located at the right abutment, is 23.8 feet wide and consists of a concrete sharp-crested weir which is triangular in cross-section. A steel channel 4 inches high is mounted on the crest of the weir. The height of the weir is 2.8 feet and both the upstream and downstream faces of the weir have slopes of 1H:1V. Three 18 inch corrugated metal pipes pass through the weir (see Appendix D, Sheet 1, for front view of spillway). The spillway training walls are concrete block and extend a minimum of 4 feet above the crest of the weir. A covered wooden bridge has been built over the spillway. The low chord of the bridge ranges from 2.0 feet to 2.5 feet above the crest of the weir.

The spillway discharge channel consists of a concrete apron which extends approximately 10 feet downstream from the crest of the weir. At the end of this apron, flow passes over a drop approximately 5 feet high to an earth-lined channel. The discharge channel then runs along the downstream toe of the

embankment for approximately 175 feet. There is no riprap or other channel protection for this section of the discharge channel.

The outlet works consist of an 18 inch corrugated metal pipe controlled by two 12 inch gate valves at the inlet to the pipe. The pipe, according to the design plan, is encased in 6 inches of concrete and has three concrete anti-seep collars located at 20 foot spacings. The outlet works are currently inoperable.

b. Location - Kenda Dam is located approximately 3000 feet upstream of Rillton, Westmoreland County, Pennsylvania on an unnamed tributary of Little Sewickley Creek. The dam and reservoir can be found on the USGS 7.5 minute topographic quadrangle, Irwin, Pennsylvania. The coordinates of the dam are N 40° 17.7' and W 79° 43.7'.

c. Size Classification - The height of the dam is 18.8 feet and the storage at the top of dam elevation is 116 acre-feet. The dam is therefore in the "Small" size category.

d. Hazard Classification - Several warehouses, garages, and a few residential structures located approximately 1000 to 2000 feet downstream from the dam would suffer economic damage if the dam were to fail. Loss of life in these structures is a possibility. The dam is therefore considered to be in the "High" hazard category.

e. Ownership - The dam and impoundment is owned by the Westmoreland Recreation Society, Inc., 2740 Clay Pike Road, North Huntingdon, PA 15642. Mr. Joseph Cassarino, Attorney at Law, 124 South Pennsylvania Avenue, Greensburg, PA 15601 was the individual responding to the contact letter mailed to this organization.

f. Purpose of the Dam - The dam and lake are used for recreational purposes.

g. Design and Construction History - Kenda Dam was originally designed and built for the Westmoreland Coal Company (dates of original construction unknown). The structure was abandoned by the coal company and breached sometime between 1932 and 1937. In 1952, Mr. Romeo Chiappini of Jeannette, Pennsylvania, purchased the dam and reservoir area and began reconstruction of the embankment.

Mr. Ralph Wilps, P.E., of Greensburg, Pennsylvania, was the engineer responsible for the specifications and plans for reconstruction of the dam. Construction began sometime in 1952 and was not fully completed until 1955. A detailed discussion of the available design and construction information is presented in Section 2.

h. Normal Operating Procedures - The reservoir level is controlled by flow through the spillway since the outlet works are inoperable. There are no records of major floods which have resulted in overtopping of the dam.

1.3 PERTINENT DATA

a. Drainage Area (square miles) -	0.80
b. Discharge at Dam Site (c.f.s.) -	
Spillway Capacity at Maximum Pool (El. 1022.8 ft. Mean Sea Level [M.S.L.]) -	297
c. Elevation (feet above M.S.L.) -	
Design Top of Dam -	1027.0[1]
Minimum Top of Dam -	1022.8
Average Top of Dam -	1024.0
Normal Pool -	1018.9
Streambed at Toe of Dam -	1004.0
d. Reservoir (feet) -	
Length of Maximum Pool -	1450
Length of Normal Pool -	1390
e. Storage (acre-feet) -	
Normal Pool (El. 1018.9 ft. M.S.L.) -	69
Top of Dam (El. 1022.8 ft. M.S.L.) -	116
f. Reservoir Surface (acres) -	
Normal Pool (El. 1018.9 ft. M.S.L.) -	10.10
Top of Dam (El. 1022.8 ft. M.S.L.) -	13.74
g. Dam -	
Type -	Earthfill
Length (feet) -	450

[1]From available design plans, Plate 3.

Height (feet) - 18.8
Top Width (feet)[2] - 10
Side Slopes - Upstream - 1.5H:1V
Downstream - ranges from 1H:1V to 1.5H:1V
Zoning - A 3 foot thick clay blanket was placed on the upstream slope. No other zoning information is available.
Impervious Core - Portions of an original concrete core wall were left in place during reconstruction. Also, a new concrete core wall was installed in some areas of the dam. Details of "as built" conditions are not available.
Cut-off Trench - Unknown
Drains - None

h. Diversion and Regulating Tunnel - None

i. Spillway -

Type - Concrete, sharp-crested, triangular weir with three 18 inch corrugated metal pipes through the weir.
Length of Crest Perpendicular to Flow (feet) - 23.8
Crest Elevation of Weir (feet M.S.L.) - 1021.0
Invert Elevation of 18 Inch Pipes (feet M.S.L.) - 1018.9
Upstream Channel - Concrete bottom approach channel
Downstream Channel - Concrete bottom discharge apron extending 10 feet downstream from the crest of the weir. This is followed by a 5 foot drop to an earth-lined channel which runs along the toe of the embankment for 175 feet.

j. Regulating Outlets - An 18 inch corrugated metal pipe with two 12 inch gate valves on the intake to the pipe. However, the outlet for these facilities could not be located.

[2]Actual top width varies from 10 feet to over 40 feet. At the narrowest section, by the spillway, the crest is only 10 feet wide.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The information reviewed for this inspection was obtained from the Pennsylvania Department of Environmental Resources' (PennDER) File No. 65-118. The earliest records of the dam date back to 1952 when reconstruction of the dam was initiated. The detailed records of the original structure built for the Westmoreland Coal Company are not available. The information contained in the file includes the following information:

1) The permit application for reconstruction of the dam, dated 15 October 1952.

2) The initial design plans and specifications for reconstruction of the dam prepared by Ralph Wilps, P.E., of Greensburg, Pennsylvania.

3) Various pieces of correspondence containing revisions to the design of the dam recommended by the Water and Power Resources Board (predecessor of PennDER).

4) Inspection reports filed by engineers from the Water and Power Resources Board. Inspections were made both during and after the reconstruction of the dam. Photographs taken during the reconstruction work are also on file. On the last report, filed on 10 April 1964, the only recommendation made was to remove trees growing on the downstream face of the embankment.

2.2 CONSTRUCTION

Kenda Dam was originally designed and built for the Westmoreland Coal Company and used as a water supply source for its boiler facilities. The dam was reportedly built along and partly against an existing railroad fill. It was later abandoned by the coal company and breached sometime between 1932 and 1937. No other information concerning the design or construction of the original dam is available.

In 1952, Mr. Romeo Chiappini of Jeannette, Pennsylvania, purchased the dam and reservoir area and began to reconstruct the embankment. The required reconstruction work consisted of repairing the center of the dam where it had been breached, building a new spillway, clearing and regrading the embankment, and installing outlet

works. Some of this work was begun before the permit for the dam was filed on 15 October 1952 and before an experienced engineer had been contracted to assist in the reconstruction of the dam. After filing the permit application, Mr. Ralph Wilps, P.E., of Greensburg, Pennsylvania, was engaged to prepare the specifications and plans for the required work.

The nature of the work performed prior to the filing of the permit application is unknown. After this date, a concrete cut-off wall was constructed in the breach to repair this area. Outlet works consisting of an 18 inch corrugated metal pipe controlled by two 12 inch gate valves at the entrance to the pipe were installed. A clay blanket 3 feet thick was then bulldozed over the entire upstream face of the embankment.

After completion of the spillway, outlet works, and embankment, the impoundment was filled sometime around the summer of 1954. Large riprap slabs were then placed on the upper portion of the upstream face of the embankment. This work, completed on August 1955, was the final step taken in reconstructing the dam.

Sometime after completion of the dam, a large amount of fill was added to the downstream side of the embankment. This was apparently done to provide an area on the crest of the dam where the owners could build recreational facilties such as picnic tables and several small structures.

There are a number of discrepancies between the "as built" conditions for the dam and those shown on the design plans in PennDER's file. Some of these differences resulted from the owner supplying PennDER and the building contractor with two different sets of plans, neither of which apparently contained all of the revisions made in the design of the dam. These discrepancies and other changes made after completion of the dam are listed below.

1) The spillway was designed to be 25 feet wide in order to have the capacity required by PennDER. It was constructed only 23.8 feet wide.

2) The three 18 inch corrugated metal pipes which run through the spillway weir are not shown on the design plans.

3) A steel channel was supposed to be installed along the crest of the spillway weir to

protect the concrete. Instead, the contractor flattened the crest of the weir and installed the steel channel to form a sharper weir crest. The edge of the steel channel forms the crest of the weir.

4) The crest of the dam is shown on the design plans as being at Elevation 1027.0 feet M.S.L., 6 feet above the crest of the triangular weir. The top of dam profile surveyed during the field inspection shows that none of the embankment is at this elevation. The average crest elevation is currently 1024.0 feet M.S.L., the minimum crest elevation is 1022.8 feet M.S.L.

5) The control for the outlet works is shown on the design plans as being an 18 inch gate valve. This was changed during construction to two 12 inch gate valves.

6) The original crest width of the dam was designed to be 10 feet. With the addition of the fill to the downstream side of the embankment, the crest width currently ranges from 10 feet at the spillway to over 40 feet at several sections. The side slopes of this fill is also much steeper than the design slope for the embankment (ranging from 1H:1V to 1.5H:1V as compared with the design slope of 2H:1V).

7) Riprap protection for the entire length of the spillway discharge channel was also part of the original specifications for the dam. No evidence of any protective measures in the discharge channel was observed during the inspection.

8) The riprap protection for the upstream face of the embankment was supposed to be placed from the toe of the slope to two feet above normal pool. The water level at the time of the inspection was 1.2 feet above normal pool, and, in several areas, was above the level of the riprap protection.

9) Cut-off walls for the spillway/embankment and spillway/abutment junctions are shown on the design drawings; however, no cut-off walls were observed in the field.

2.3 OPERATION

The owner of the dam, Westmoreland Recreation Society, Inc., is responsible for maintenance and operation of the dam.

2.4 EVALUATION

a. Availability - The information used in this report is readily available from PennDER File No. 65-118.

b. Adequacy - The information available combined with the information collected during the inspection of this dam is adequate for a Phase I Inspection.

c. Validity - The PennDER file does not contain revisions made to the design plans. Because of this, the information which is available is incomplete.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General - The inspection was performed on 14 December 1979. No unusual weather conditions were experienced and the water in the impoundment was at Elevation 1020.1 feet M.S.L., 1.2 feet above normal pool. The dam and appurtenant structures were found to be in poor overall condition. Noteworthy deficiencies observed during the visual inspection are described in the following paragraphs. The complete visual inspection check list, field sketch, top of dam profile, and typical cross-section are presented in Appendix A.

b. Dam - The following is a list of obvious deficiencies noted during the visual inspection of the embankment.

1) Several tension cracks were observed on the downstream edge of the crest at Station 2+50.

2) The spillway discharge channel runs along the toe of the embankment for approximately 175 feet. Flow in this channel is eroding the downstream toe of the dam.

3) Run-off from the crest of the dam has formed several erosion gullies on the downstream face of the dam at Stations 2+25 and 2+75.

4) The material on the downstream face of the embankment is very loose, resulting in a gradual sloughing and deterioration of the embankment in several areas.

5) The vertical alignment of the crest of the dam is uneven. The top of dam profile shows that the crest of the dam slopes in towards the center of the dam. The minimum crest elevation is at Station 2+00 where the crest is almost 2 feet below the top of dam elevation at the spillway and at the left abutment.

6) The downstream face of the embankment along the spillway discharge channel is covered with trees and brush. Several of the trees on this area of the embankment have fallen into or across the discharge channel.

7) Small erosion gullies have developed behind both spillway training walls on the downstream face of the embankment. The discharge from the spillway is undercutting the downstream slope at the left end of the spillway.

c. Appurtenant Structures - The following is a list of deficiencies observed during the visual inspection of the dam's appurtenant structures.

1) The outlet structure could not be located. It may have been buried by material sloughing off the downstream face of the dam. It could also have been covered when the additional fill was added to the downstream face of the dam.

2) Some minor spalling and cracking of the concrete weir has taken place, primarily near the crest of the weir. A small amount of water is flowing through the cracks.

3) The approach to the spillway is clogged with a great deal of debris, partially blocking the flow of water through the three corrugated metal pipes in the weir.

4) The discharge channel is clogged with a variety of debris, much of which is trash that has been dumped down in the channel.

5) The spillway discharge apron is being undermined in several places at the end, especially on both sides near the training walls.

6) Timbers which were stacked on the downstream edge of the crest of the dam have fallen into the discharge channel, partially blocking the flow of water.

d. Reservoir Area - The slopes of the drainage basin and reservoir are moderate to steep. A majority of the watershed is forested with some new residential development in the upper end of the basin.

e. Downstream Channel - The slope of the downstream channel is moderate. Several residential structures, warehouses, and a few garages are located approximately 1000 to 2000 feet downstream from the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no formal procedures for operating the reservoir or evacuating the downstream area in case of an impending failure of the dam. It is recommended that formal emergency procedures be adopted.

4.2 MAINTENANCE OF DAM

The owner of the dam, Westmoreland Recreational Society, Inc., is responsible for maintenance of the dam. Generally, the maintenance procedures followed are considered to be extremely poor. A program which would keep the spillway and discharge channel free of debris, prevent trees and brush from growing on the dam, and prevent deterioration of the slopes of the dam should be adopted by the owner.

4.3 MAINTENANCE OF OPERATING FACILITIES

The operating facilities which are reported to be in the dam, specifically, the 18 inch outlet pipe, could not be located during the field inspection. It is recommended that the owner engage the services of a professional engineer experienced in earth dams and appurtenant structures to restore the operation of outlet works or provide an alternate drawdown system.

4.4 DESCRIPTION OF ANY EMERGENCY WARNING SYSTEM IN EFFECT

There is no warning system or procedure in the event of an impending dam failure. Emergency procedures should be developed to notify residents downstream.

4.5 EVALUATION OF OPERATIONAL ADEQUACY

The maintenance and operation of Kenda Dam are considered to be poor. More rigorous programs to protect the dam from the deterioration it has undergone should be instituted.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data - There is no detailed hydrologic or hydraulic design information available for Kenda Dam.

b. Experience Data - No records of the performance of the dam during significant flood events is available. There is no indication that the dam has ever been overtopped.

c. Visual Observation - The crest of the embankment slopes towards the center of the dam where the minimum crest elevation is 1022.8 feet M.S.L. at Station 2+00. This point is approximately 1.2 feet below the average crest elevation (1024.0 feet M.S.L.).

A large amount of debris has collected in front of the spillway weir, partially blocking the entrances to three pipes through the weir.

The outlet channel from the spillway leads along the downstream toe of the embankment for approximately 175 feet. High flows in this channel would erode the toe of the embankment since the embankment is not protected by any riprap or similar material.

d. Overtopping Potential - Kenda Dam is a "Small" size - "High" hazard dam requiring analysis for a spillway design flood (SDF) in the range of the 1/2 Probable Maximum Flood (1/2 PMF) to the Probable Maximum Flood (PMF). Because of the relatively small size of the drainage area and impoundment, the 1/2 PMF was selected as the SDF.

The hydraulic capacity of the dam, reservoir, and spillway was assessed by utilizing the U.S. Army Corps of Engineers' Flood Hydrograph package, HEC-1 DB. The hydrologic characteristics of the drainage basin, specifically, the Snyder's unit hydrograph parameters, were obtained from a regionalized analysis conducted by the Baltimore District of the Corps of Engineers.

Analysis of the dam, reservoir, and spillway shows that the dam would be overtopped by the SDF. The depth and total duration of overtopping are 1.24 feet and 7.00 hours, respectively.

The spillway is capable of passing approximately 17 percent of the PMF before overtopping of the dam occurs.

e. Spillway Adequacy - The dam, as outlined in the above analysis, would be overtopped by the SDF. The long duration and large depth of overtopping, combined with the poor condition of the embankment, make it likely that the dam will fail during the 1/2 PMF. To assess the impact of the dam's failure on the damage centers downstream, the 1/2 PMF was routed through the dam for failure and non-failure conditions. This analysis indicated that there would be a significant increase in flow depth and quantity from the non-failure to the failure case. It is likely that there would be a significant increase in downstream damages accompanying the increase in flow. The spillway is therefore considered to be "seriously inadequate".

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations - The erosion and undercutting of the embankment at the discharge end of the spillway indicates concern for the continued stability and safety of the embankment at this location. Although the actual head on the embankment at this location is small (approximately 10 feet maximum), it is also the location of the thinnest section of the embankment (approximately 35 feet maximum at the base).

The tension cracks and bulging observed at Station 2+50 are probably the result of end dumping coal waste material over the edge of the slope to increase the top width of the embankment.

The presence of large diameter (approximately 12 inches maximum) trees on the downstream embankment is undesirable and the trees and their root system should be properly removed.

Additional features which are undesirable from a structural stability standpoint are the presence of erosion gullies on the downstream face, the absence of the cut-off walls at the junctions of the spillway and the embankment/abutment, and the undesirable condition of having the spillway discharge channel placed along the downstream toe of the embankment.

b. Design and Construction Data - Calculations of slope and structural stability were not available for review. Given the current condition of the embankment slopes and the uncertainties in the design and construction of Kenda Dam, it is recommended that an overall detailed review of the dam, including quantitative assessments of the stability of the dam, be performed in the near future by a qualified professional engineer experienced in the design and construction of earth dams.

c. Operating Records - No operating records were available for review. No operational procedures or information was provided to the inspection team.

d. Post-Construction Changes - The known post-construction change of placing additional fill on the downstream slope was not undertaken in a controlled manner. This material appears to be end dumped. Instability is indicated by the tension cracks and bulging of the slope at Station 2+50 and also the erosion gullies formed in this material at Stations 2+25 and 2+75. It is recommended that the effects this post-construction change has on the future performance of the dam be evaluated as a part of the overall detailed investigation of this dam.

e. Seismic Stability - Kenda Dam is located in Seismic Zone 1 on the "Seismic Zone Map of the Contiguous United States," Figure 1, page D-30, "Recommended Guidelines for Safety Inspection of Dams". This is a zone of minor seismic activity. Experience indicates that dams located in these zones will have adequate stability under seismic loading conditions if they have adequate stability under static loading conditions. As indicated in paragraph 6.1.b., further assessment of the static stability is recommended. If the evaluation and subsequent recommendations provide sufficient static stability factors of safety, then further evaluations of the seismic stability are not warranted.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety - Kenda Dam was found to be in poor overall condition at the time of inspection.

Kenda Dam is a "High" hazard - "Small" size dam requiring a spillway design flood (SDF) in the range of the 1/2 PMF to PMF. The 1/2 PMF was selected as the SDF because of the small size of the drainage area and impoundment. As presented in Section 5, the spillway and reservoir are not capable of passing the 1/2 PMF without overtopping the dam. During the 1/2 PMF, the dam is overtopped by a maximum depth of 1.24 feet for a total duration of 7.00 hours. It is estimated that, in its present condition, the dam is likely to fail during the 1/2 PMF. Further Phase I analysis indicated that there would be a significant increase in downstream damages if the dam were to fail as compared with the non-failure conditions. The spillway is therefore considered to be "seriously inadequate".

The erosion and undercutting of the embankment; the tension cracks, bulging, and localized sloughing of the embankment; and the uncertainties of the design and construction of the dam all indicate concern for the continued stability and safety of this dam. It is recommended that a detailed overall investigation of this dam be performed. Therefore, the dam is classified as being in an "Unsafe" - "Non-Emergency" condition.

b. Adequacy of Information - The design and "as built" construction information is superficial at best. The observations and measurements made during the field inspection, combined with the information which could be assembled from the PennDER file, are considered adequate for this Phase I Inspection Report. However, more information is needed to evaluate the safety of this impoundment. It is recommended that additional information be obtained as discussed in paragraph 7.1.d. below.

c. Urgency - The owner should immediately initiate the further investigation discussed in paragraph 7.1.d. and implement the recommendations in paragraph 7.2 without delay.

d. Necessity for Additional Data/Evaluation - The overall condition and uncertainties of this dam indicate that an overall detailed investigation of this dam is necessary. The owner should immediately initiate an engineering study including, but not necessarily limited to, the following items:

1) The hydraulic/hydrologic analysis performed in connection with this Phase I Inspection Report has indicated the need for additional spillway capacity. The spillway capacity should be further evaluated and recommendations developed for remedial measures to reduce the overtopping potential of the dam.

2) The slopes and overall condition of the dam has indicated the need for a quantitative assessment of the stability of the dam. This should include an investigation into the material properties of the embankment, seepage analysis and determination of the phreatic line, and stability analysis.

3) The location, condition, and measures necessary to rehabilitate the outlet works of the dam should be determined and the appropriate measures implemented.

4) The potential problems associated with the removal of the trees should be evaluated and qualified recommendations as to the best method of their removal that would produce the minimal amount of damage to the embankment should be developed and implemented.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

The inspection revealed certain items of remedial work which should be performed by the owner without delay. Items 1 through 9 below should be completed under the direction of a qualified professional engineer experienced in the design and construction of earth dams and appurtenant structures. These include:

1) The owner should immediately initiate an engineering study to further evaluate the spillway capacity and develop recommendations for remedial measures to reduce the overtopping potential of the dam.

2) The owner should initiate an engineering study to provide a quantitative assessment of

the dam stability and develop recommendations for remedial action as necessary. Material property investigations, piezometers, and seepage analysis should be an integral part of this study.

3) The location, condition, and operability of the outlet works should be determined. If the current outlet works cannot be used for drawdown of the reservoir, then the outlet works should be rehabilitated or an alternate drawdown system developed.

4) The trees on the downstream slope of the dam should be removed. Prior to the removal of these trees, however, the owner should initiate an engineering study concerning the potential problems associated with their removal. This study should result in recommendations as to the best method of removal that would produce minimal damage to the embankment while eliminating the possibility of voids in the embankment forming as a result of a decaying root system.

5) As a part of the aforementioned studies, the "as built" condition of the dam should be determined and recorded on engineering drawings for future reference.

6) The erosion and undercutting of the toe of the embankment should be repaired and appropriate measures taken to prevent any future undercutting/erosion.

7) The erosion gullies on the downstream face of the dam should be repaired. Proper erosion control measures, i.e., vegetative cover, should be placed on the downstream slope to minimize erosion.

8) It is recommended that the dam be raised at a minimum to Elevation 1025.5 feet M.S.L. (top of spillway training walls).

9) The undermining of the end of the discharge apron should be repaired and measures taken to prevent future undermining.

10) The debris at the crest of the spillway and at the inlets of the corrugated metal pipes in the crest should be removed and efforts made in the future to remove this debris as it accumulates.

11) The debris which has collected in the discharge channel of the spillway should be removed. This includes the debris at the end of the discharge apron, the debris which has been dumped into the discharge channel from the embankment crest, and the timbers which have fallen from the embankment crest into the channel.

In addition, the following operational measures are recommended to be undertaken by the owner:

1) Develop a detailed emergency operation and warning system.

2) During periods of unusually heavy rain, provide around-the-clock surveillance of the dam.

3) When warning of a storm of major proportions is given by the National Weather Service, the owner should activate the emergency operation and warning system.

It is further recommended that formal inspection, maintenance, and operation procedures and records be developed and implemented.

APPENDIX A

VISUAL INSPECTION CHECK LIST, FIELD SKETCH, TOP OF DAM PROFILE, AND TYPICAL CROSS-SECTION

Check List
Visual Inspection
Phase 1

Name of Dam Kenda Dam County Westmoreland State PA Coordinates Lat. N 40°17.7'

NDI # PA 00459
PennDER # 65-118

Long. W 79°43.7'

Date of Inspection 14 December 1979 Weather Clear Temperature 40° F.

Pool Elevation at Time of Inspection 1020.1 ft.* M.S.L. Tailwater at Time of Inspection 1013.2 ft.* M.S.L.

*All elevations reference to crest of weir, El. 1021.0 ft. M.S.L.

Inspection Personnel:

Michael Baker, Jr., Inc.:

James G. Ulinski
Jeff Maze
Wayne D. Lasch

Owner's Representatives:

Field Review (18 March 1980)

John A. Dziubek
James G. Ulinski

James G. Ulinski Recorder

CONCRETE/MASONRY DAMS - Not Applicable

Name of Dam: KENDA DAM

NDI # PA 00459

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
LEAKAGE		
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS		
DRAINS		
WATER PASSAGES		
FOUNDATION		

CONCRETE/MASONRY DAMS - Not Applicable

Name of Dam: KENDA DAM

NDI # PA 00459

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES		
STRUCTURAL CRACKING		
VERTICAL AND HORIZONTAL ALIGNMENT		
MONOLITH JOINTS		
CONSTRUCTION JOINTS		

EMBANKMENT

Name of Dam KENDA DAM

NDI # PA 00459

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	Several tension cracks were observed on the downstream edge of the crest of the dam at Station 2+50.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	The spillway discharge channel runs along the toe of the embankment for approximately 175 ft. Flow in this channel is eroding the downstream toe of the dam. Run-off from the crest of the dam has also formed several erosion gullies on the downstream face of the dam at Stations 2+25 and 2+75. The material on the downstream face of the dam is also very loose, resulting in gradual sloughing and deterioration of the slope along most of its length.	The embankment should be protected from erosion and undercutting. All areas where erosion and undercutting have occurred should be repaired.

EMBANKMENT

Name of Dam KENDA DAM

NDI # PA 00459

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	The vertical alignment of the crest is uneven. The top of dam profile shows that the crest of the dam slopes in towards the center of the dam. The minimum crest elevation is at Station 2+00 where the crest is almost 2 ft. below the top of dam elevation at the spillway training walls and at the left abutment.	The top of dam should be raised at a minimum to the top of the spillway training walls (El. 1025± ft. M.S.L.)
RIPRAP FAILURES	None was observed. The water level at the time of the inspection was above the riprap at several locations.	
VEGETATION	The downstream face of the embankment along the spillway discharge channel is covered with trees and brush. Several of the trees on this area of the embankment have fallen into or across the discharge channel.	The trees and brush should be removed from the dam and discharge channel.

EMBANKMENT

Name of Dam KENDA DAM

NDI # PA 00459

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Small erosion gullies have developed behind both spillway training walls on the downstream face of the dam.	The erosion gullies should be repaired.
ANY NOTICEABLE SEEPAGE	None observed	
STAFF GAGE AND RECORDER	None	
DRAINS	None	

OUTLET WORKS

Name of Dam: KENDA DAM
NDI # PA 00459

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	The outlet structure could not be located during the field inspection.	The location, condition, and operability of the outlet works should be verified. If these facilities cannot be used for drawdown of the reservoir, then they should be rehabilitated or an alternative drawdown system developed.
INTAKE STRUCTURE	Submerged at time of inspection.	
OUTLET STRUCTURE	The outlet structure could not be located during the field inspection. It may have been buried by material sloughing off the downstream face of the dam.	The location, condition, and operability of the outlet works should be verified. If these facilities cannot be used for drawdown of the reservoir, then they should be rehabilitated or an alternative drawdown system developed.
OUTLET CHANNEL	None observed	
EMERGENCY GATE	None observed	

UNGATED SPILLWAY

Name of Dam: KENDA DAM

NDI # PA 00459

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Some minor spalling and cracking of the concrete weir has taken place, primarily near the crest of the weir. A small amount of water is flowing through the cracks. The weir has not been constructed according to the plans contained in the PennDER file.	The cracks should be properly sealed.
APPROACH CHANNEL	The approach to the spillway is clogged with a great deal of debris, partially blocking the flow of water through the three 18 in. C.M.P.'s which run through the weir.	Remove the debris from the spillway and prevent debris from accumulating in the future.
DISCHARGE CHANNEL	The discharge channel is clogged with assorted types of debris (fallen trees, garbage, refrigerators, etc.). The spillway discharge apron is being undermined in several places.	Remove all the debris from the discharge channel. Repair the end of the discharge apron where undermined and install adequate protection to prevent future undermining.
BRIDGE AND PIERS	A covered wooden bridge has been constructed over the spillway. The alignment of the spillway training walls, which forms the foundation for the bridge deck, appears to be satisfactory.	

GATED SPILLWAY - Not Applicable

Name of Dam: KENDA DAM

NDI # PA 00459

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL		
APPROACH CHANNEL		
DISCHARGE CHANNEL		
BRIDGE AND PIERS		
GATES AND OPERATION EQUIPMENT		

INSTRUMENTATION - None

Name of Dam: KENDA DAM

NDI # PA 00459

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS		
OBSERVATION WELLS		
WEIRS		
PIEZOMETERS		
OTHER		

RESERVOIR

Name of Dam: KENDA DAM

NDI # PA 00459

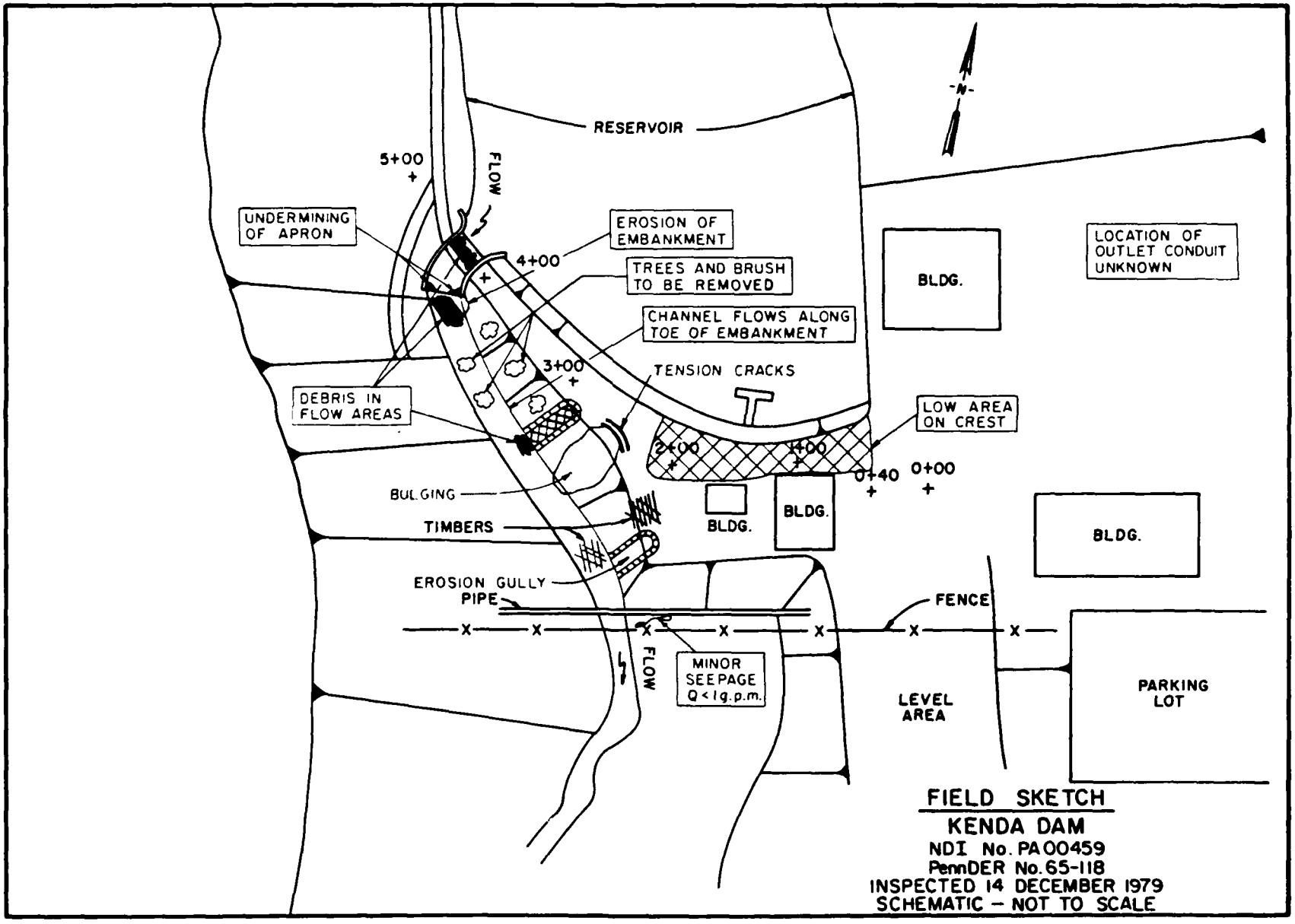
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	The slopes of the reservoir area are moderately steep. Most areas are covered by woods with some residential development.	
SEDIMENTATION	No large accumulation of sediment was observed in the reservoir.	

DOWNSTREAM CHANNEL

Name of Dam: KENDA DAM

NDI # PA 00459

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	A large amount of debris is clogging the downstream channel. Large timbers stacked on the crest of the dam have fallen into the channel. Other debris, dumped down the downstream face of the dam, is blocking the channel.	Remove all the debris from the downstream channel, including the timbers which have fallen into the channel.
SLOPES	Slopes of the downstream area are moderate and primarily covered by woods.	
APPROXIMATE NO. OF HOMES AND POPULATION	Two residential structures, several warehouses, and a few garages are located approximately 1000 ft. downstream of the dam.	

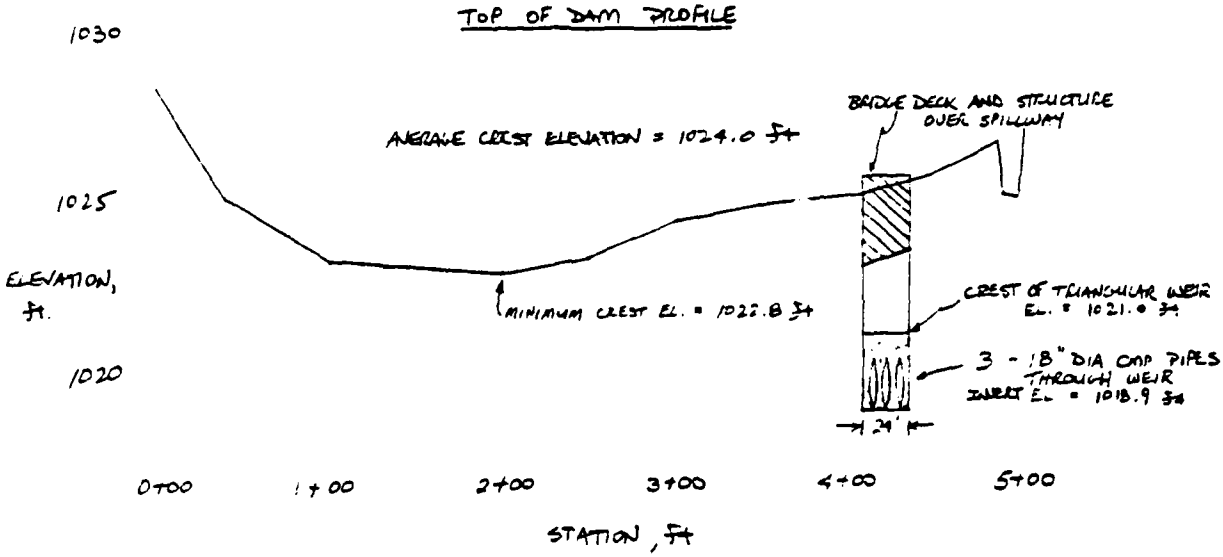

RESERVOIR
N
5+00
FLOW
UNDERMINING OF APRON
EROSION OF EMBANKMENT
4+00
TREES AND BRUSH TO BE REMOVED
CHANNEL FLOWS ALONG TOE OF EMBANKMENT
3+00
TENSION CRACKS
DEBRIS IN FLOW AREAS
LOW AREA ON CREST
2+00
1+00
0+40
0+00
BULGING
TIMBERS
BLDG.
BLDG.
BLDG.
BLDG.
LOCATION OF OUTLET CONDUIT UNKNOWN
EROSION GULLY
PIPE
FENCE
FLOW
MINOR SEEPAGE Q < 1 g.p.m.
LEVEL AREA
PARKING LOT
FIELD SKETCH
KENDA DAM
NDI No. PA00459
PennDER No. 65-118
INSPECTED 14 DECEMBER 1979
SCHEMATIC – NOT TO SCALE

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS
18 March 1980
Box 280
Beaver, Pa. 15009

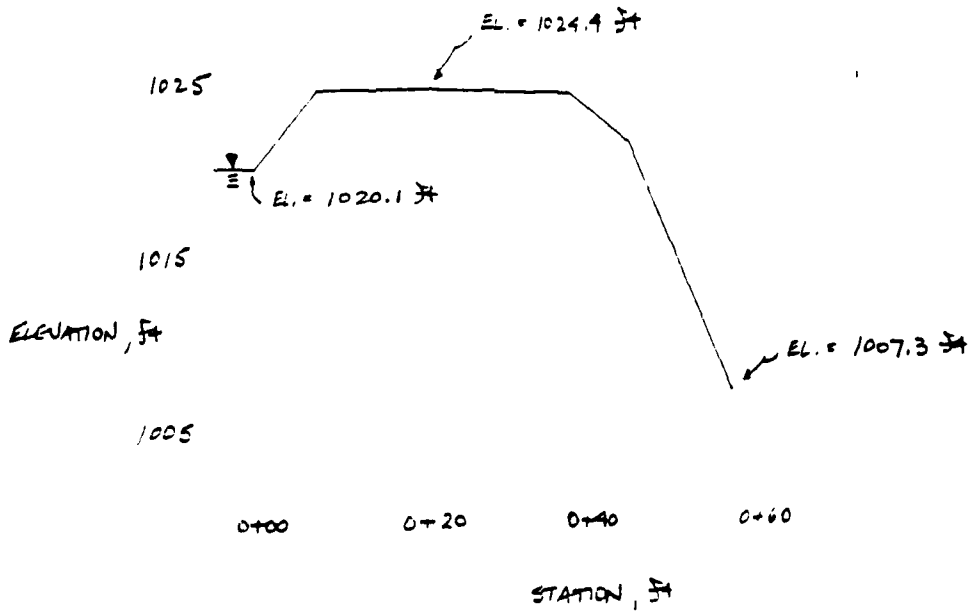
TOP OF DAM PROFILE
TYPICAL CROSS-SECTION

DATE OF INSPECTION - 14 December 1979

TOP OF DAM PROFILE



CROSS-SECTION AT STATION 3+00



APPENDIX B

ENGINEERING DATA CHECK LIST

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Name of Dam: KENDA DAM
NDI # PA 00459

ITEM	REMARKS
PLAN OF DAM	A set of design plans for the dam are available in the PennDER file. Several relatively major changes were made during the construction of the dam. As best as could be determined, these changes are explained in Sections 2 and 3.
REGIONAL VICINITY MAP	A USGS 7.5 minute quadrangle, Irwin, Pennsylvania, was used to prepare the vicinity map which is enclosed in this report as the Location Plan (Plate 1).
CONSTRUCTION HISTORY	The dam was originally constructed for the Westmoreland Coal Company (date unknown). It was breached sometime between 1932-1937. Reconstruction of the dam begin in 1952 and was completed in 1955.
TYPICAL SECTIONS OF DAM	See Page A-14 for typical sections of dam.
HYDROLOGIC/HYDRAULIC DATA	No information available
OUTLETS - PLAN, DETAILS, CONSTRAINTS, and DISCHARGE RATINGS	No "as built" plans are available.
RAINFALL/RESERVOIR RECORDS	None available

Name of Dam: KENDA DAM

NDI # PA 00459

ITEM	REMARKS
DESIGN REPORTS	A set of design plans are available. However, these plans are not complete and do not accurately represent the current conditions of the dam.
GEOLOGY REPORTS	None are available. The regional geology is presented as Appendix F of this report.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	No information available
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	No information available
POST-CONSTRUCTION SURVEYS OF DAM	None
BORROW SOURCES	No information available

Name of Dam: KENDA DAM

NDI # PA 00459

ITEM	REMARKS
MONITORING SYSTEMS	None
MODIFICATIONS	The modifications made to the dam are discussed in Section 2.
HIGH POOL RECORDS	No information available
POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None reported in the information available.
MAINTENANCE OPERATION RECORDS	No formal records are maintained.

Name of Dam: KENDA DAM

NDI # PA 00459

ITEM	REMARKS
SPILLWAY PLAN, SECTIONS, and DETAILS	No "as built" information available.
OPERATING EQUIPMENT PLANS & DETAILS	No "as built" information available.

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 0.80 sq.mi. (Medium density residential)

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1018.9 ft. M.S.L. (69 ac.-ft.)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 1022.8 ft. M.S.L. (116 ac.-ft.)

ELEVATION MAXIMUM DESIGN POOL: Unknown

ELEVATION TOP DAM: 1022.8 ft. M.S.L. (minimum elevation)

SPILLWAY:

a. Crest Elevation 1018.9 ft. M.S.L. (invert El. of C.M.P.'s through weir)
b. Type 3-18 in. dia. C.M.P's through sharp crested triangular weir
c. Width of Crest Parallel to Flow 3.4 ft. bottom width
d. Length of Crest Perpendicular to Flow 23.8 ft.
e. Location Spillover Right abutment
f. Number and Type of Gates None

OUTLET WORKS:

a. Type 18 in. diameter C.M.P.
b. Location Center of embankment
c. Entrance Inverts Unknown
d. Exit Inverts Unknown
e. Emergency Drawdown Facilities The outlet works could not be located

HYDROMETEOROLOGICAL GAGES: None

a. Type
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE No records available

APPENDIX C

PHOTOGRAPH LOCATION PLAN AND PHOTOGRAPHS

DETAILED PHOTOGRAPH DESCRIPTIONS

Overall View of Dam

Top Photo (OV-T) - View of Upstream Side of Dam from the Left Abutment

Bottom Photo (OV-B) - View of Upstream Side of Dam from the Right Abutment

Photograph Location Plan

Photo 1 - View of the Entrance to Spillway (Note amount of debris present)

Photo 2 - View Looking Upstream at the Downstream Side of the Spillway Structure (Note the debris off the end of the apron)

Photo 3 - View of the Left End (Junction with embankment) of the Spillway (Note the amount of erosion of the embankment and also note the location of the yellow jug in this photo and photo 4)

Photo 4 - Close-up View of Erosion and Undercutting of the Embankment Shown in Photo 3

Photo 5 - View Looking Upstream at the Downstream Slope of the Embankment and Debris in Channel

Photo 6 - View Looking Downstream at Debris in Channel and Erosion of Downstream Slope of the Embankment

Photo 7 - View of the Crest of the Dam at the Location of the Tension Cracks (Note tension crack in left center of photo)

Photo 8 - View of Tension Cracks at Crest of the Downstream Slope

Note: Photographs were taken on 14 December 1979.

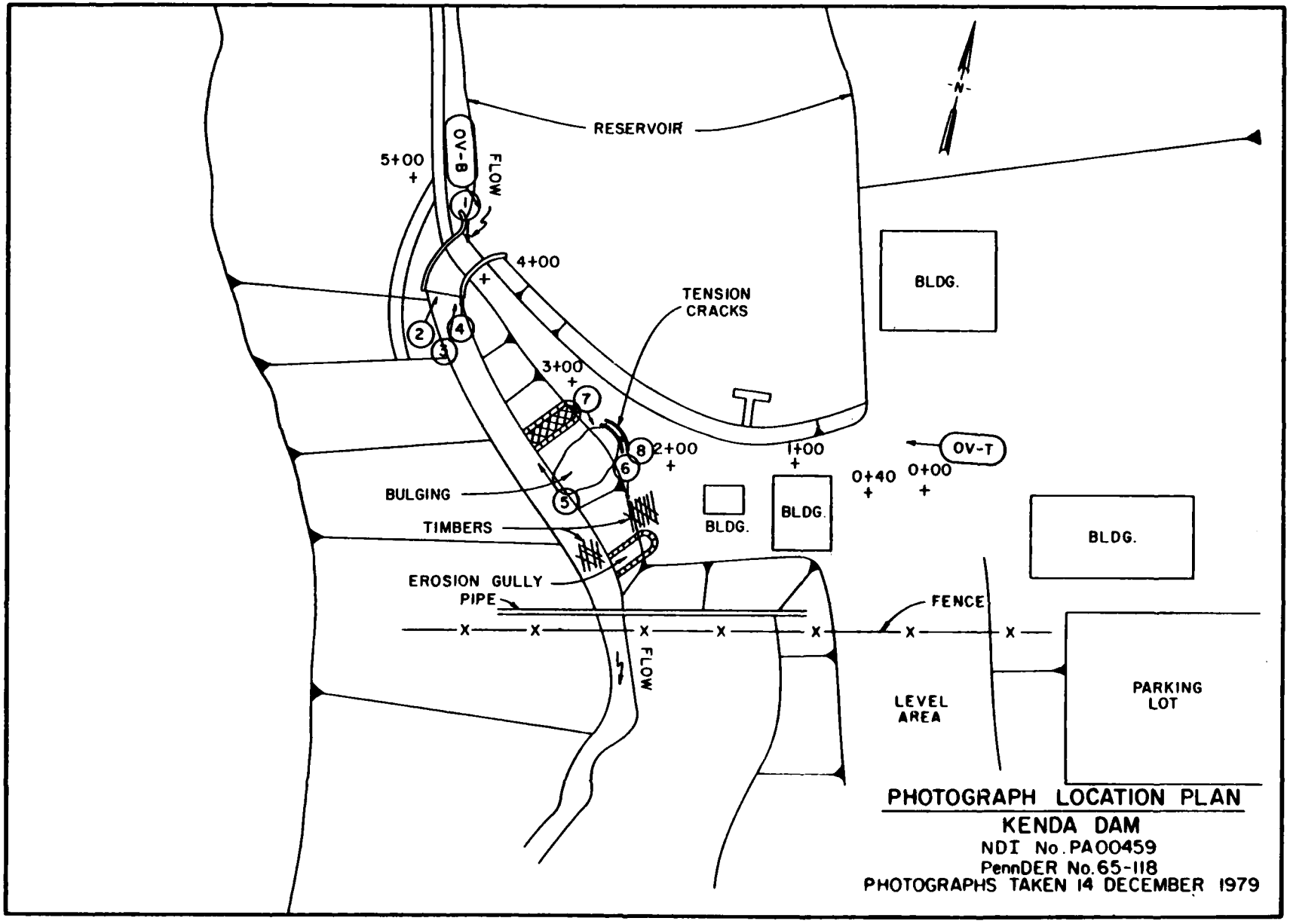

RESERVOIR
N
OV-B
FLOW
5+00
4+00
TENSION
CRACKS
BLDG.
3+00
2+00
1+00
OV-T
0+40
0+00
BULGING
TIMBERS
BLDG.
BLDG.
BLDG.
EROSION GULLY
PIPE
FENCE
FLOW
LEVEL
AREA
PARKING
LOT
PHOTOGRAPH LOCATION PLAN
KENDA DAM
NDI No. PA00459
PennDER No. 65-118
PHOTOGRAPHS TAKEN 14 DECEMBER 1979

PHOTO 1. View of the Entrance to Spillway (Note amount of debris present)

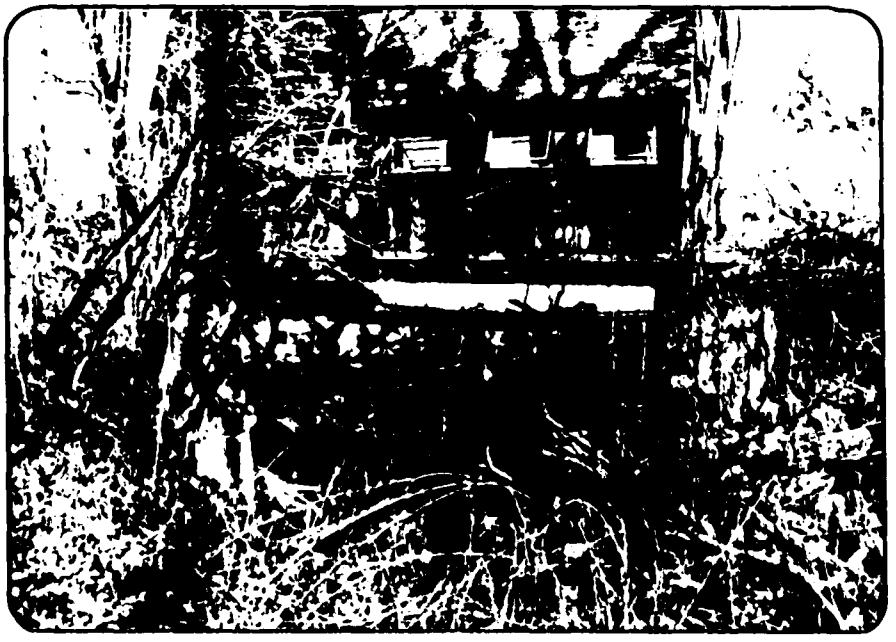


PHOTO 2. View Looking Upstream at the Downstream Side of the Spillway Structure (Note the debris off the end of the apron)

PHOTO 3. View of the Left End (Junction with Embankment) of the Spillway

PHOTO 4. Close-up View of Erosion and Undercutting of the Embankment Shown in Photo 3

PHOTO 5. View Looking Upstream at the Downstream Slope of the Embankment and Debris in Channel

PHOTO 6. View Looking Downstream at Debris in Channel and Erosion of Downstream Slope of the Embankment

PHOTO 7. View of the Crest of the Dam at the Location of the Tension Cracks (Note tension crack in left center of photo)

PHOTO 8. View of Tension Cracks at Crest of the Downstream Slope

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject KENDA DAM ... S.O. No. _____
APPENDIX D - HYDROLOGIC AND Sheet No. _____ of _____
HYDRAULIC COMPUTATIONS Drawing No. _____
Computed by _____ Checked by _____ Date _____

SUBJECT	PAGE

PREFACE

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

The hydrologic determinations presented in this Phase I Inspection Report are based on the use of a Snyder's unit hydrograph developed by the U.S. Army Corps of Engineers. Due to the limited number of gaging stations available in this hydrologic region and the wide variations of watershed slopes, the Snyder's coefficients may yield results of limited accuracy for this watershed. As directed however, a further refinement of these coefficients is beyond the scope of this Phase I Investigation.

In addition, the conclusions presented pertain to present conditions, and the effect of future development on the hydrology has not been considered.

HYDROLOGY AND HYDRAULIC ANALYSIS
DATA BASE

NAME OF DAM: KENDA DAM

PROBABLE MAXIMUM PRECIPITATION (PMP) = 24.0 INCHES/24 HOURS[1]

STATION	1	2	3	4	5
Station Description	KENDA DAM				
Drainage Area (square miles)	0.80				
Cumulative Drainage Area (square miles)	0.80				
Adjustment of PMF for Drainage Area (%)[2]	Zone 7				
6 Hours	102				
12 Hours	120				
24 Hours	130				
48 Hours	140				
72 Hours	--				
Snyder Hydrograph Parameters					
Zone [3]	25				
C_p/C_t [4]	0.40/1.0				
L (miles) [5]	1.50				
L_{ca} (miles)[5]	0.67				
$t_p = C_t (L \cdot L_{ca})^{0.3}$ (hours)	1.00				
Spillway Data					
Crest Length (ft)	25				
Freeboard (ft)	3.9				
Discharge Coefficient	(Rating curve developed on sheets 7-9)				
Exponent					

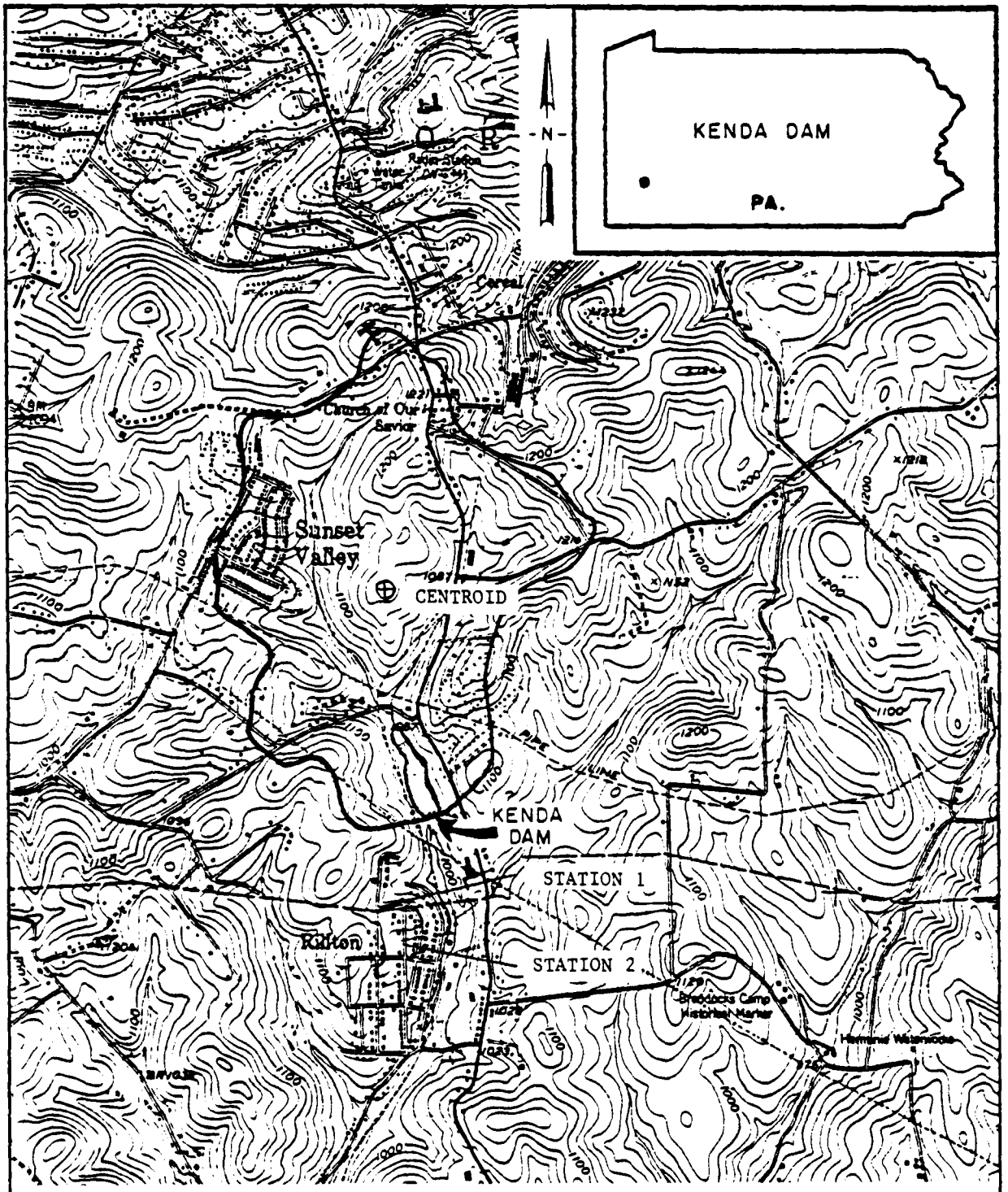
[1] Hydrometeorological Report 33 (Figure 1), U.S. Army, Corps of Engineers, 1956.

[2] Hydrometeorological Report 33 (Figure 2), U.S. Army, Corps of Engineers, 1956.

[3] Hydrological zone defined by Corps of Engineers, Baltimore District, for determining Snyder's Coefficients (C_p and C_t).

[4] Snyder's Coefficients.

[5] L = Length of longest water course from outlet to basin divide.
L_{ca} = Length of water course from outlet to point opposite the centroid of drainage area.

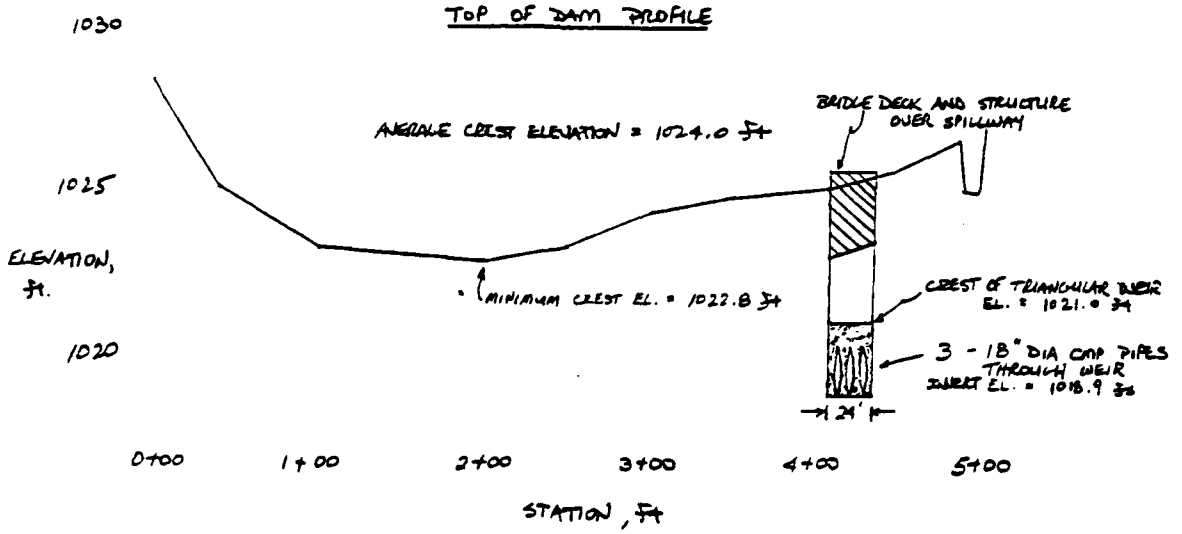


KENDA DAM
DRAINAGE AREA MAP

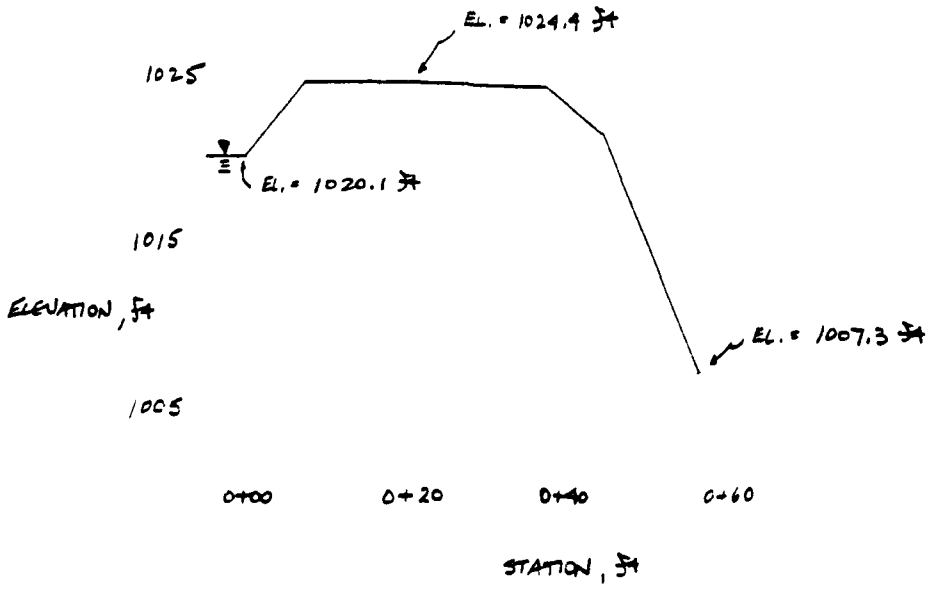
MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS
Box 280
Beaver, Pa. 15009

Subject KENDA DAM — S.O. No.
DAM CREST PROFILE AND — Sheet No. 3 of 20
CROSS SECTION — Drawing No.
Computed by WDL — Checked by WLS — Date 3-18-80

TOP OF DAM PROFILE



CROSS-SECTION AT STATION 3+00



MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject KENDA DAM — S.O. No.
HYDRAULIC DATA — Sheet No. 4 of 20
Drawing No.
Computed by WDL — Checked by — Date 3-18-80

STORAGE CALCULATIONS :

ELEVATION VS. AREA DATA (MEASURED FROM QUADS) :

ELEVATION Ft.	AREA, ACRES
1018.9	10.10
1020	11.94
1040	24.79

NOTE: NORMAL POOL ASSUMED TO BE AT EL. 1018.9 Ft

NORMAL POOL STORAGE :

$$V_{NP} = \frac{h}{3}\left(A_1 + A_2 + \sqrt{A_1 A_2}\right)$$

h = AVERAGE DEPTH = 7 Ft (ESTIMATED FROM SOUNDINGS)

A_1 = AREA OF NORMAL POOL = 10.1 Ac

A_2 = AREA OF RESERVOIR BOTTOM = 9.6 Ac. (ESTIMATED FROM DEPTH AND GROUND SLOPES)

$$V_{NP} = \frac{7}{3}\left(10.1 + 9.6 + \sqrt{(10.1)(9.6)}\right)$$

$V_{NP} = 68.9$ Ac-Ft

TOP OF DAM STORAGE :

STORAGE AT TOP OF DAM = 116 Ac-Ft (FROM HEC-1 ANALYSIS)

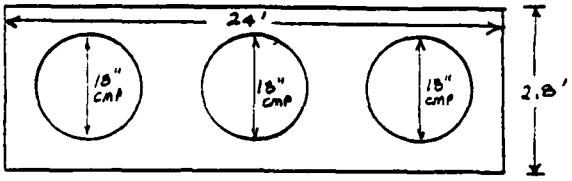
MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

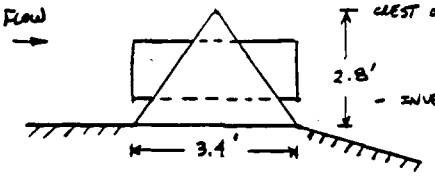
Subject KENDA DAM — S.O. No.
SPILLWAY RATING CURVE — Sheet No. 5 of 20
Drawing No.
Computed by WDL — Checked by JAC — Date 3-18-80

FLOW THROUGH THE SPILLWAY IS CONTROLLED BY A TRIANGULAR, SHARP-CRESTED WEIR AND THREE 18" DIA. PIPES THROUGH THE WEIR.

FRONT VIEW OF SPILLWAY



SIDE VIEW



SPILLWAY DISCHARGE CHANNEL HAS A 5% SLOPE FOR 10 Ft. THEN THERE IS A 5' DROP TO STREAM LEVEL.

RATING FOR OPEN CHANNEL FLOW THROUGH THE 3 PIPES:

ELEVATION, Ft	DEPTH, Y, Ft	Y/d_o	$Z/d_o^{2.5}$	A/d_o^2	Z	A	Q (FOR 1 PIPE)	V	$V^2/2g$	EGL
1018.9	0	-	-	-	-	-	0	-	-	-
1019.0	0.1	0.07	0.0053	0.0242	0.015	0.054	0.085	1.57	0.038	1019.04
1019.5	0.6	0.40	0.1603	0.2939	0.442	0.660	2.508	3.80	0.224	1019.72
1020.0	1.1	0.73	0.5100	0.6143	1.405	1.382	7.973	5.77	0.517	1020.52
1020.3	1.4	0.93	0.9292	0.7612	2.561	1.713	14.532	8.48	1.11	1021.41

d_o = DIAMETER OF PIPES = 1.5 Ft

A = FLOW AREA IN 1 PIPE (Ft^2)

Q = FLOW, CFS

V = VELOCITY, Ft/sec

$V^2/2g$ = VELOCITY HEAD ($g = 32.2$ Ft/sec)

EGL = ENERGY GRADE LINE ELEV., Ft.

Z = SECTION FACTOR FOR CRITICAL FLOW

FACTORS $Z/d_o^{2.5}$ AND A/d_o^2 WERE TAKEN FROM P 625, OPEN CHANNEL FLOW, CHOW.

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject KENDA DAM S.O. No.
SPILLWAY RATING CURVE Sheet No. 6 of 20
Drawing No.
Computed by WDL Checked by JJC Date 3-18-80

ELEVATION VS. DISCHARGE FOR 3 PIPES TOGETHER (OPEN CHANNEL FLOW ONLY):

ELEVATION, Ft	Q, cfs, FOR 1 PIPE	Q FOR 3 PIPES
1018.9	0	0
1019.04	0.085	0.255
1019.72	2.508	7.529
1020.52	7.973	23.919
1021.41	14.532	43.596

RATING OF ORIFICE FLOW THROUGH PIPES:

$Q = CA\sqrt{2gH}$

C = 0.74 (FROM BRATER & KING, HANDBOOK OF HYDRAULICS, P. 4-37)

A = 1.77 Ft^2 (AREA OF 1 PIPE)

g = 32.2 Ft/sec^2

H = HEAD MEASURED TO CENTER OF PIPE, Ft.

ELEVATION, Ft	Q, cfs, FOR 1 PIPE	Q, cfs, FOR 3 PIPES
1020.4	9.103	27.31
1021.0	12.21	36.64
1022.0	16.11	48.34
1023.0	19.24	57.72

RATING OF WEIR FLOW:

$Q = CLH^{3/2}$

L = 23.8 Ft

C = 4.11 (FROM BRATER AND KING, HANDBOOK OF HYDRAULICS, P. 5-42)

ELEVATION, Ft	Q, cfs
1021.0	0
1022.0	97.92
1023.0	276.96

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

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Beaver, Pa. 15009

Subject KENDA DAM — S.O. No.
SPILLWAY RATING CURVE AND — Sheet No. 7 of 20
FAILURE ASSUMPTIONS — Drawing No.
Computed by WDL — Checked by JHC — Date 3-18-80

COMBINED DISCHARGE RATING FOR SPILLWAY :

ELEVATION, Ft	Q_{TOTAL}, cfs
1018.9	0
1019.04	0.26
1019.72	7.52
1020.4	27.31
1021.0	36.64
1022.0	146.26
1023.0	334.68

FAILURE ASSUMPTIONS :

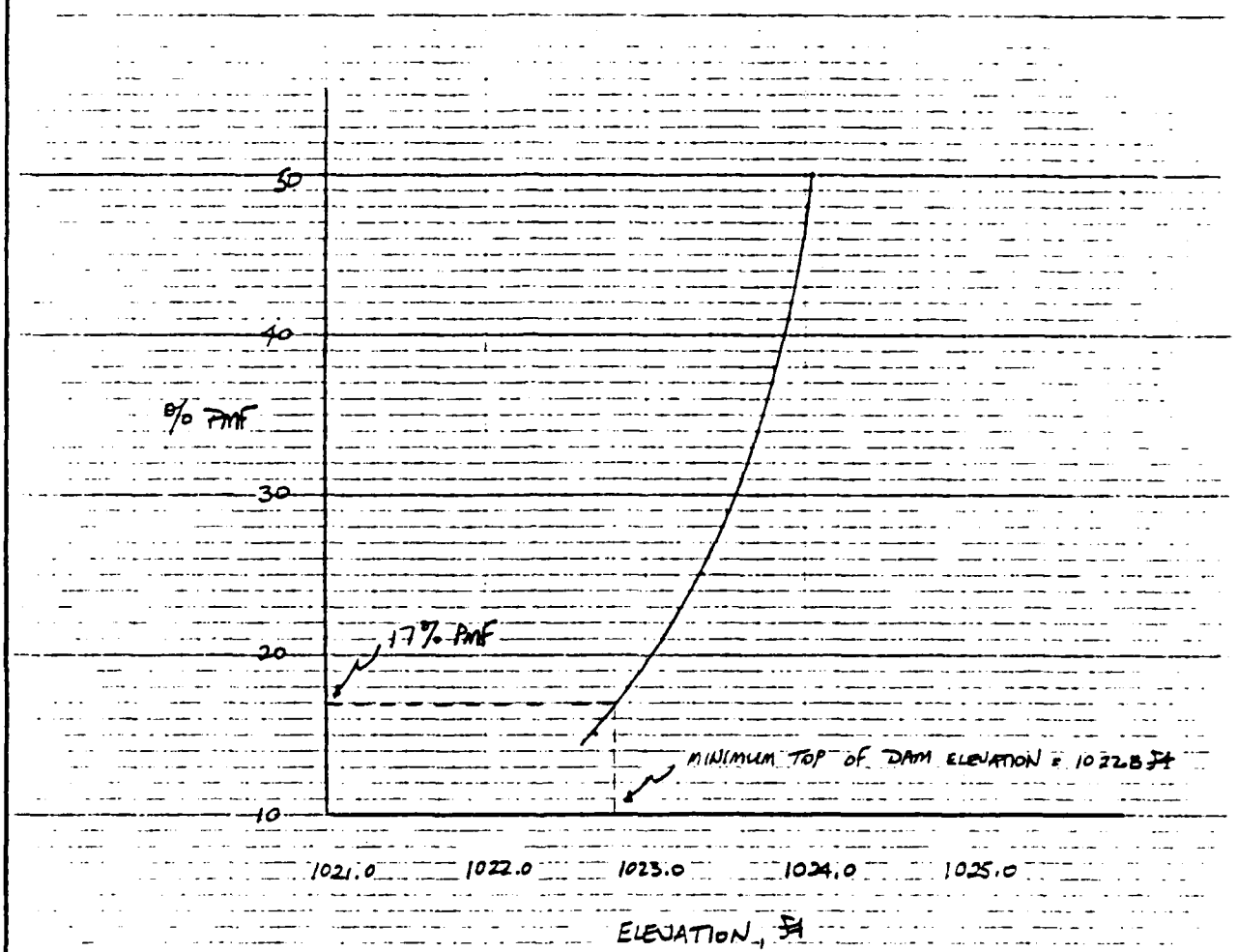
1. DURATION OF FAILURE = 1.0 HOUR
2. DAM FAILS TO BOTTOM OF RESERVOIR (EL. 1011.9 Ft)
3. BOTTOM WIDTH OF BREACH IS 100 Feet (FROM STATION 1+30 TO 2+30), SIDE SLOPE OF BREACH IS 2H:1V.

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject KENDA DAM
SPILLWAY CAPACITY ANALYSIS

S.O. No.
Sheet No. 8 of 20
Drawing No.
Computed by WDL Checked by Date 3-18-80



SPILLWAY CAPACITY ANALYSIS

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
 LAST MODIFICATION  24 FEB 79
 MAY UPDATE         04 JUN 79
**********
    1              A1       NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
    2              A2       HYDROLOGIC AND HYDRAULIC ANALYSES OF KENDA DAM
    3              A3       UNIT HYDROGRAPH BY SNYDERS METHOD
    4              B    300         0        30         0         0         0         0         0        -4         0
    5              B1     5
    6              J      1         4         1
    7              J1  0.50      0.25      0.15      0.05
    8              K                1                                                  1
    9              K1       RUNOFF HYDROGRAPH TO DAM                                                    1
   10              M      1         1      0.80
   11              P      0        24       102       120       130       140
   12              T                                                          1.0      0.05
   13              W   1.00      0.40
   14              X   -1.5     -0.05       2.0                                                1
   15              K      1         2                                                  1
   16              K1       ROUTING FOR KENDA DAM
   17              Y                                    1         1
   18              Y1     1                                                 -1018.9        -1
   19              Y41018.9  1019.04  1019.72  1020.4  1021.0  1022.0  1023.0
   20              Y5     0      0.26      7.52     27.31     36.64    146.26    334.68
   21              $A   9.6      10.1      11.9      24.8
   22              $E1011.9  1019.0  1020.0  1040.0
   23              $$1018.9
   24              $D1022.8     3.08       1.5       423
   25              $L     0        62        88       174       213       262       347       375       409       439
   26              $V1022.8  1022.9  1023.0  1023.5  1024.0  1024.5  1025.0  1025.5  1026.0  1026.5
   27              K     99
```

SHEET 9 OF 20

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**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
  MOD UPDATE         04 JUN 79
**********************************

RUN  DATE 06/23/80
     TIME    11.32
```

NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
HYDROLOGIC AND HYDRAULIC ANALYSES OF KENDA DAM
UNIT HYDROGRAPH BY SNYDERS METHOD

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	30	0	0	0	0	0	-4	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0	0		

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1
RTIOS= 0.50 0.25 0.15 0.05

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

RUNOFF HYDROGRAPH TO DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	0.80	0.0	0.80	0.0	0.0	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	24.00	102.00	120.00	130.00	140.00	0.0	0.0

TRSPC COMPUTED BY THE PROGRAM IS 0.800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.0	0.0	1.00	0.0	0.0	1.00	1.00	0.05	0.0	0.0

UNIT HYDROGRAPH DATA
TP= 1.00 CP=0.40 NTA= 0

RECESSION DATA
STRTQ= -1.50 QRCSN= -0.05 RTIOR= 2.00

UNIT HYDROGRAPH 21 END-OF-PERIOD ORDINATES, LAG= 0.99 HOURS, CP= 0.40 VOL= 1.00

69.	178.	191.	145.	109.	83.	63.	47.	36.	27.
21.	16.	12.	9.	7.	5.	4.	3.	2.	2.
1.									

SHEET 10 OF 20

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	26.88	24.46	2.42	26379.
										(683.1)	(621.3)	(61.5)	(748.9)

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTING FOR KENDA DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	3	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.0	0.0	1	1	3	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.0	0.0	0.0	-1019.	-1

STAGE	1018.90	1019.04	1019.72	1020.40	1021.30	1022.00	1023.00
FLOW	0.0	0.26	7.52	27.31	36.04	146.26	334.66
SURFACE AREA=	10.	10.	12.	25.			
CAPACITY=	0.	70.	81.	440.			
ELEVATION=	1012.	1019.	1020.	1040.			

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
1018.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
1022.8	3.1	1.5	423.

CREST LENGTH AT OR BELOW ELEVATION	0. 1022.8	62. 1022.9	88. 1023.0	174. 1023.5	213. 1024.0	262. 1024.5	347. 1025.0	375. 1025.5	409. 1026.0	439. 1026.5

PEAK OUTFLOW IS 1079. AT TIME 41.00 HOURS

PEAK OUTFLOW IS 510. AT TIME 41.50 HOURS

PEAK OUTFLOW IS 274. AT TIME 42.00 HOURS

PEAK OUTFLOW IS 61. AT TIME 43.00 HOURS

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 0.50	RATIO 2 0.25	RATIO 3 0.15	RATIO 4 0.05
HYDROGRAPH AT	1	3.83	1	1074.	537.	322.	107.
		2.07)		30.42)(	15.21)(	9.13)(	3.04)(
ROUTED TO	2	3.83	1	1079.	510.	274.	61.
		2.07)		30.55)(	14.44)(	7.77)(	1.72)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1018.90	1018.90	1022.80
STORAGE	69.	69.	116.
OUTFLOW	0.	0.	297.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.50	1024.04	1.24	133.	1077.	7.00	41.00	0.0
0.25	1023.36	0.56	124.	513.	3.50	41.50	0.0
0.15	1022.68	0.0	115.	274.	0.0	42.00	0.0
0.05	1021.22	0.0	96.	61.	0.0	43.00	0.0

SHEET 13 OF 20

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
  MBJ UPDATE         04 JUN 79
**********
    1              A1       NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
    2              A2       HYDROLOGIC AND HYDRAULIC ANALYSES OF KENDA DAM
    3              A3       UNIT HYDROGRAPH BY SNYDERS METHOD
    4              R    500       0       5       0       0       0       0       0      -4       0
    5              B1     5
    6              J      2       1       1
    7              J1  0.50
    8              K                      1                                       1
    9              K1       RUNOFF HYDROGRAPH TO DAM
   10              M      1       1    0.80                                                  1
   11              P      0      24     102     120     130     140
   12              T                                                      1.0    0.05
   13              W   1.00    0.40
   14              X   -1.5   -0.05     2.0
   15              K      1       2                                               1
   16              K1       ROUTING FOR KENDA DAM
   17              Y                              1       1
   18              Y1     1                                       -1018.9      -1
   19              Y41018.9 1019.04 1019.72  1020.4  1021.0  1022.0  1023.0
   20              Y5     0    0.26    7.52   27.31   36.64  146.26  334.68
   21              $A   9.6    10.1    11.9    24.8
   22              $E1011.9  1019.0  1020.0  1040.0
   23              $$1018.9
   24              $D1022.8    3.08     1.5     423
   25              $L     0      62      88     174     213     262     347     375     409     439
   26              $V1022.8  1022.9  1023.0  1023.5  1024.0  1024.5  1025.0  1025.5  1026.0  1026.5
   27              $B   100       2  1011.9     1.0  1018.9  1050.0
   28              $B   100       2  1011.9     1.0  1018.9  1023.0
   29              K      1       2                                               1
   30              K1       ROUTE TO SECTION 1000 FEET DOWNSTREAM FROM DAM
   31              Y                              1       1
   32              Y1     1                                                       0
   33              Y6 0.055   0.045   0.055     986    1020    1000   0.014
   34              Y7     0    1020      70    1000     200     990     202     986     208     986
   35              Y7   210     990     300    1000     350    1020
   36              K      1       3                                               1
   37              K1       ROUTE TO SECTION 2000 FEET DOWNSTREAM FROM DAM
   38              Y                              1       1
   39              Y1     1                                                       0
   40              Y6 0.055   0.045   0.055     978    1010    1000   0.008
   41              Y7     0    1020     110    1000     240     982     242     978     248     978
   42              Y7   250     982     475    1000     520    1020
   43              K     99
```

COMPARISON OF FAILURE AND NON-FAILURE CASES

PLAN 1 = NON-FAILURE
PLAN 2 = FAILURE

SHEET 14 OF 20

****
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79
MBJ UPDATE 04 JUN 79
****

RUN DATE 04/23/80
TIME 11.06

NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
HYDROLOGIC AND HYDRAULIC ANALYSES OF KENDA DAM
UNIT HYDROGRAPH BY SNYDERS METHOD

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
500	0	5	0	0	0	0	0	-4	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 2 NRTIO= 1 LRTIO= 1

RTIOS= 0.50

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

RUNOFF HYDROGRAPH TO DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	0.80	0.0	0.80	0.0	0.0	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	24.00	102.00	120.00	130.00	140.00	0.0	0.0

TRSPC COMPUTED BY THE PROGRAM IS 0.800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.0	0.0	1.00	0.0	0.0	1.00	1.00	0.05	0.0	0.0

UNIT HYDROGRAPH DATA
TP= 1.00 CP=0.40 NTA= 0

RECESSION DATA
STRTQ= -1.50 QRCSN= -0.05 RTIOR= 2.00

UNIT HYDROGRAPH 30 END-OF-PERIOD ORDINATES, LAG= 1.01 HOURS, CP= 0.40 VOL= 0.98

4.	17.	34.	55.	79.	105.	131.	156.	176.	193.
204.	210.	208.	200.	191.	183.	175.	168.	160.	153.
147.	140.	134.	129.	123.	118.	112.	108.	103.	98.
94.	90.	86.	83.	79.	76.	72.	69.	66.	63.

SHEET 15 OF 20

61.	58.	55.	53.	51.	49.	46.	44.	42.	41.
39.	37.	36.	34.	33.	31.	30.	29.	27.	26.
25.	24.	23.	22.	21.	20.	19.	18.	18.	17.
16.	15.	15.	14.	13.	13.	12.	12.	11.	11.
10.	10.	9.	9.	9.	8.	8.	8.	7.	7.
7.	6.	6.	6.	6.	5.	5.	5.	5.	4.

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	26.88	24.46	2.42	146696.
										(683.1[	621.1[	61.1[	4153.97)

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTING FOR KENDA DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.0	0.0	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.0	0.0	0.0	-1019.	-1

STAGE	1018.90	1019.04	1019.72	1020.40	1021.00	1022.00	1023.00
FLOW	0.0	0.26	7.52	27.31	36.64	146.26	334.68
SURFACE AREA=	10.	10.	12.	25.			
CAPACITY=	0.	70.	81.	440.			
ELEVATION=	1012.	1019.	1020.	1040.			

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
1018.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
1022.8	3.1	1.5	423.

CREST LENGTH	0.	62.	88.	174.	213.	262.	347.	375.	409.	439.
AT OR BELOW ELEVATION	1022.8	1022.9	1023.0	1023.5	1024.0	1024.5	1025.0	1025.5	1026.0	1026.5

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
100.	2.00	1011.90	1.00	1018.90	1050.00

PEAK OUTFLOW IS 1061. AT TIME 40.75 HOURS

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
100.	2.00	1011.90	1.00	1018.90	1023.00

BEGIN DAM FAILURE AT 38.75 HOURS

PEAK OUTFLOW IS 1944. AT TIME 39.35 HOURS

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE TO SECTION 1000 FEET DOWNSTREAM FROM DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.0	0.0	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.0	0.0	0.0	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
0.0550	0.0450	0.0550	986.0	1020.0	1000.	0.01400

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
0.0 1020.00 70.00 1000.00 200.00 990.00 202.00 986.00 208.00 986.00
210.00 990.00 300.00 1000.00 350.00 1020.00

STORAGE	0.0	0.28	0.64	1.52	3.98	8.05	13.74	21.04	29.95	39.70
	49.88	60.51	71.58	83.09	95.04	107.43	120.26	133.54	147.25	161.41
OUTFLOW	0.0	55.59	172.82	427.99	1129.05	2561.95	4960.66	8531.68	13615.98	20832.60
	29391.28	39256.66	50410.42	62845.25	76560.88	91562.75	107859.38	125462.50	144386.19	164645.44
STAGE	986.00	987.79	989.58	991.37	993.16	994.95	996.74	998.53	1000.31	1002.10
	1003.89	1005.68	1007.47	1009.26	1011.05	1012.84	1014.63	1016.42	1018.21	1020.00
FLOW	0.0	55.59	172.82	427.99	1129.05	2561.95	4960.66	8531.68	13615.98	20832.60
	29391.28	39256.66	50410.42	62845.25	76560.88	91562.75	107859.38	125462.50	144386.19	164645.44

MAXIMUM STAGE IS 993.0

MAXIMUM STAGE IS 994.2

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE TO SECTION 2000 FEET DOWNSTREAM FROM DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
3	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME

SHEET 17 OF 20

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPAP	LSTR
0.0	0.0	0.0	1	1	3	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0.	0	0.0	0.0	0.0	0.	0.

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
0.0550	0.0450	0.0550	978.0	1010.0	1000.	0.00800

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.0 1020.00 110.00 1000.00 240.00 982.00 242.00 978.00 248.00 978.00
250.00 982.00 475.00 1000.00 520.00 1020.00

STORAGE	0.0	0.26	0.59	1.23	3.06	6.17	10.57	16.26	23.22	31.47
	41.01	51.83	63.93	77.32	91.65	106.49	121.83	137.67	154.02	170.88
OUTFLOW	0.0	38.10	118.10	270.05	660.64	1457.91	2799.32	4805.24	7585.45	11242.14
	15871.70	21565.88	28412.57	36496.37	47017.41	58861.09	71939.50	86249.19	101790.63	118567.50
STAGE	978.00	979.68	981.37	983.05	984.74	986.42	988.10	989.79	991.47	993.16
	994.84	996.52	998.21	999.89	1001.58	1003.26	1004.95	1006.63	1008.31	1010.00
FLOW	0.0	38.10	118.10	270.05	660.64	1457.91	2799.32	4805.24	7585.45	11242.14
	15871.70	21565.88	28412.57	36496.37	47017.41	58861.09	71939.50	86249.19	101790.63	118567.50

MAXIMUM STAGE IS 985.6

MAXIMUM STAGE IS 987.0

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1
				0.50
HYDROGRAPH AT	1	0.80	1	1083.
	(	2.07)	(	30.68)(
			2	1083.
			(	30.68)(
ROUTED TO	2	0.80	1	1061.
	(	2.07)	(	30.05)(
			2	1938.
			(	54.89)(
ROUTED TO	2	0.80	1	1060.
	(	2.07)	(	30.02)(
			2	1933.
			(	54.74)(
ROUTED TO	3	0.80	1	1059.
	(	2.07)	(	29.98)(
			2	1923.
			(	54.46)(

RATIOS APPLIED TO FLOWS

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 NON FAILURE

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1018.90	1018.90	1022.80
STORAGE	69.	69.	116.
OUTFLOW	0.	0.	297.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.50	1024.03	1.23	133.	1061.	6.58	40.75	0.0

PLAN 2 FAILURE

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1018.90	1018.90	1022.80
STORAGE	69.	69.	116.
OUTFLOW	0.	0.	297.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.50	1023.01	0.21	119.	1944.	0.48	39.35	38.75

PLAN 1 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
0.50	1060.	993.0	40.83

PLAN 2 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
0.50	1933.	994.2	39.42

AT STATION 1, 1000 FT. DOWNSTREAM FROM THE DAM, STAGE INCREASES 1.2 FEET AND FLOW INCREASES 873 cfs FROM THE NON-FAILURE TO FAILURE CASE.

PLAN 1 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
0.50	1059.	985.6	40.83

PLAN 2 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
0.50	1923.	987.0	39.42

AT STATION 2, 2000 FT. DOWNSTREAM FROM THE DAM, STAGE INCREASES 1.4 FEET AND FLOW INCREASES 864 cfs FROM THE NON-FAILURE TO FAILURE CASE.

SHEET 30 OF 30

APPENDIX E

PLATES

CONTENTS

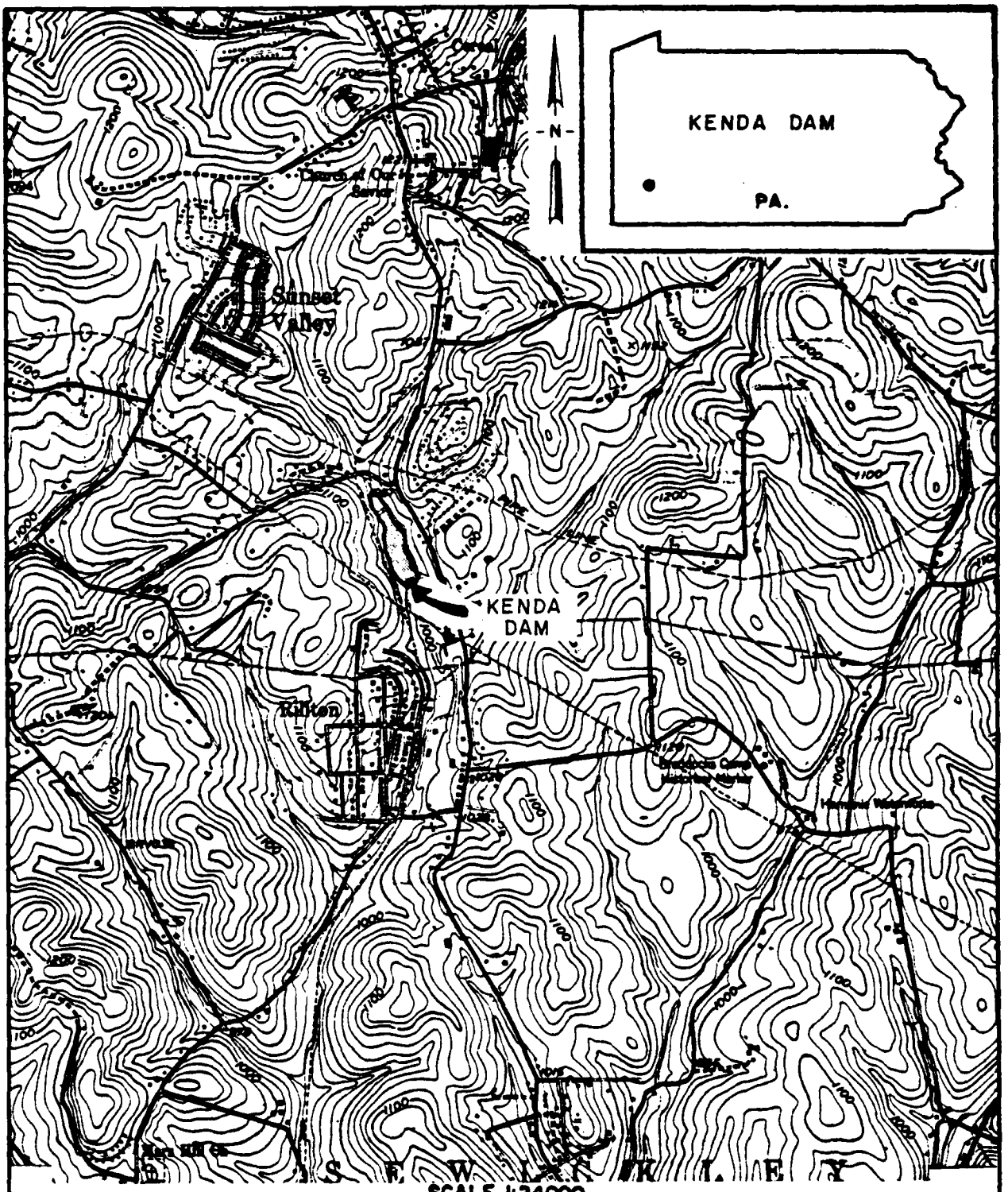


PLATE 1 LOCATION PLAN

KENDA DAM

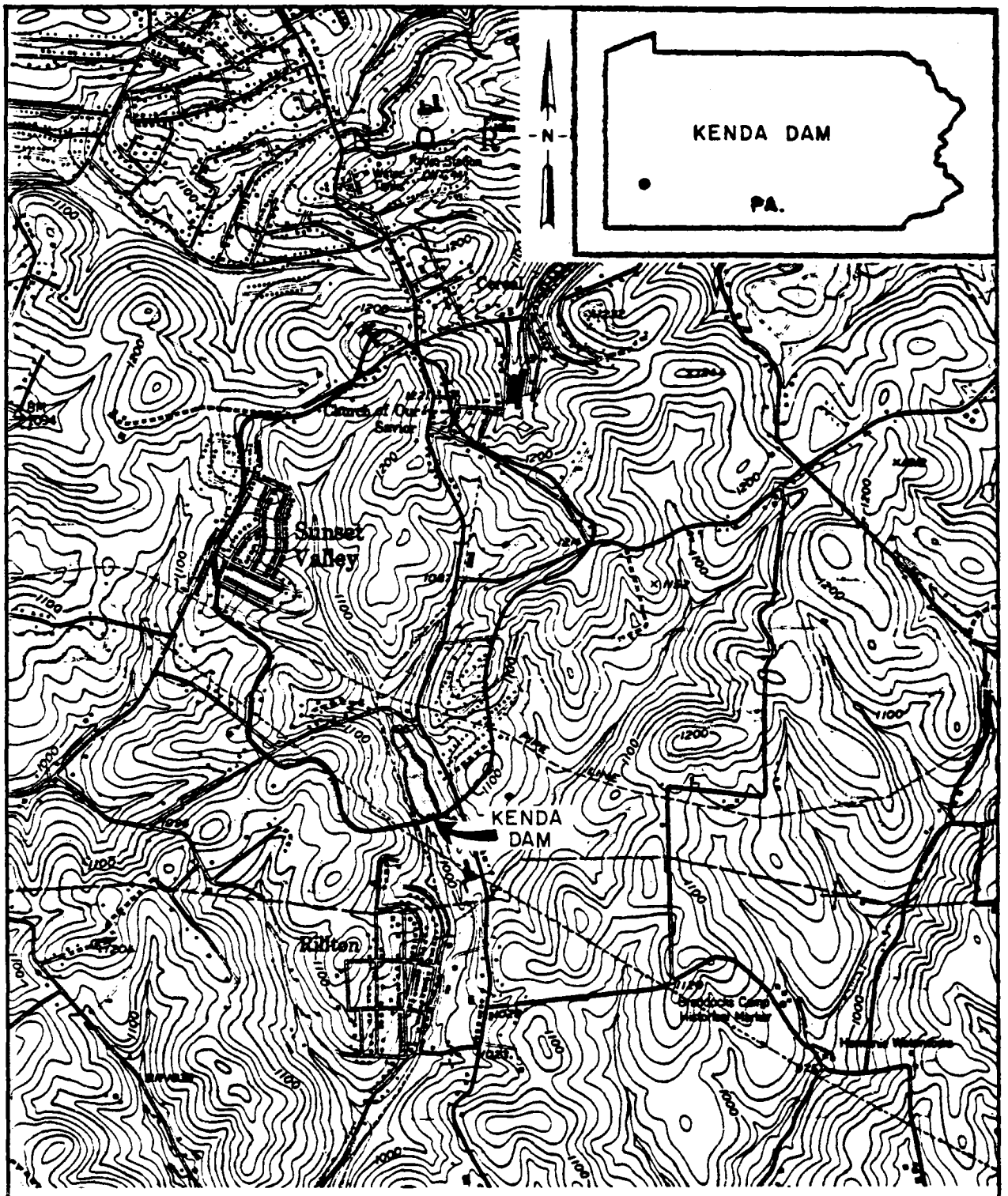
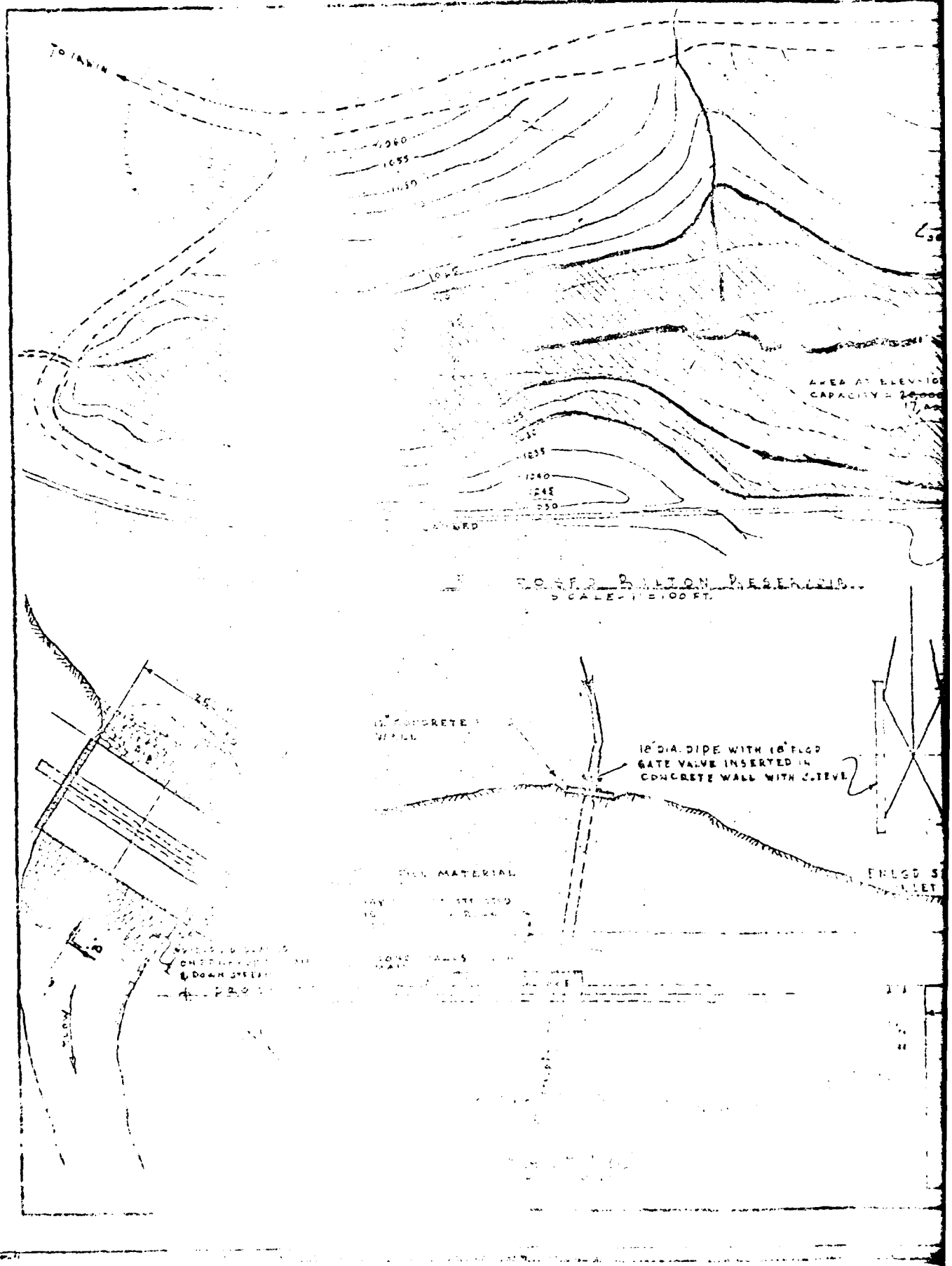


PLATE 2 WATERSHED MAP

KENDA DAM


TO TABLE
1060
1055
1050
1045
1040
1035
1030
AREA AT ELEV 10
CAPACITY =
FORD BIXTON RESERVOIR
SCALE 1" = 100 FT.
18" DIA. PIPE WITH 18" FLGD GATE VALVE INSERTED IN CONCRETE WALL WITH STEVE
FILL MATERIAL
FLGD S
SLEET

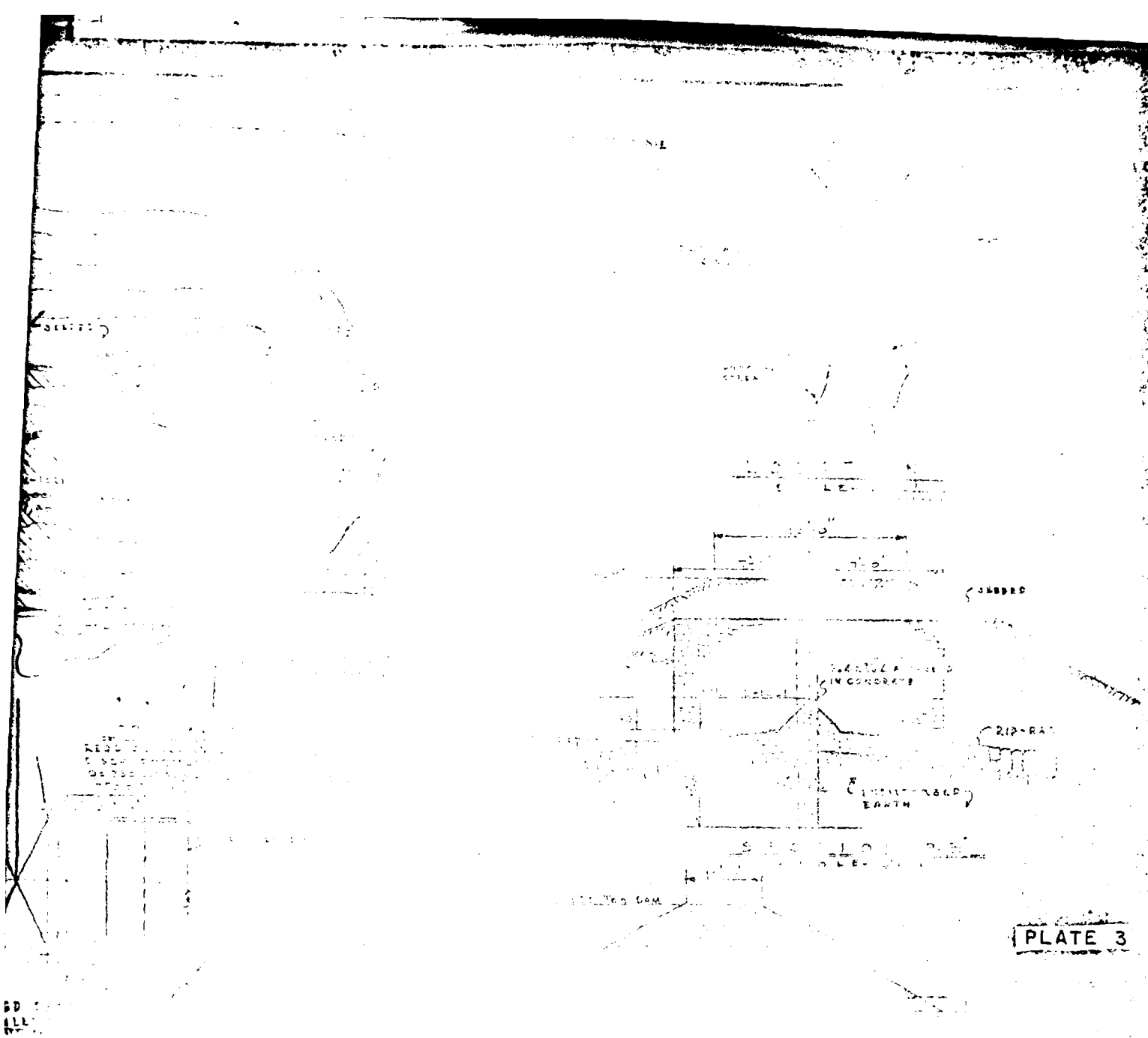


PLATE 3

NOTE THIS DESIGN DRAWING IS NOT REPRESENTATIVE OF THE "AS BUILT" CONDITIONS. SEE THE TEXT AND FIELD SKETCH FOR "AS BUILT" CONDITIONS.

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APPENDIX F

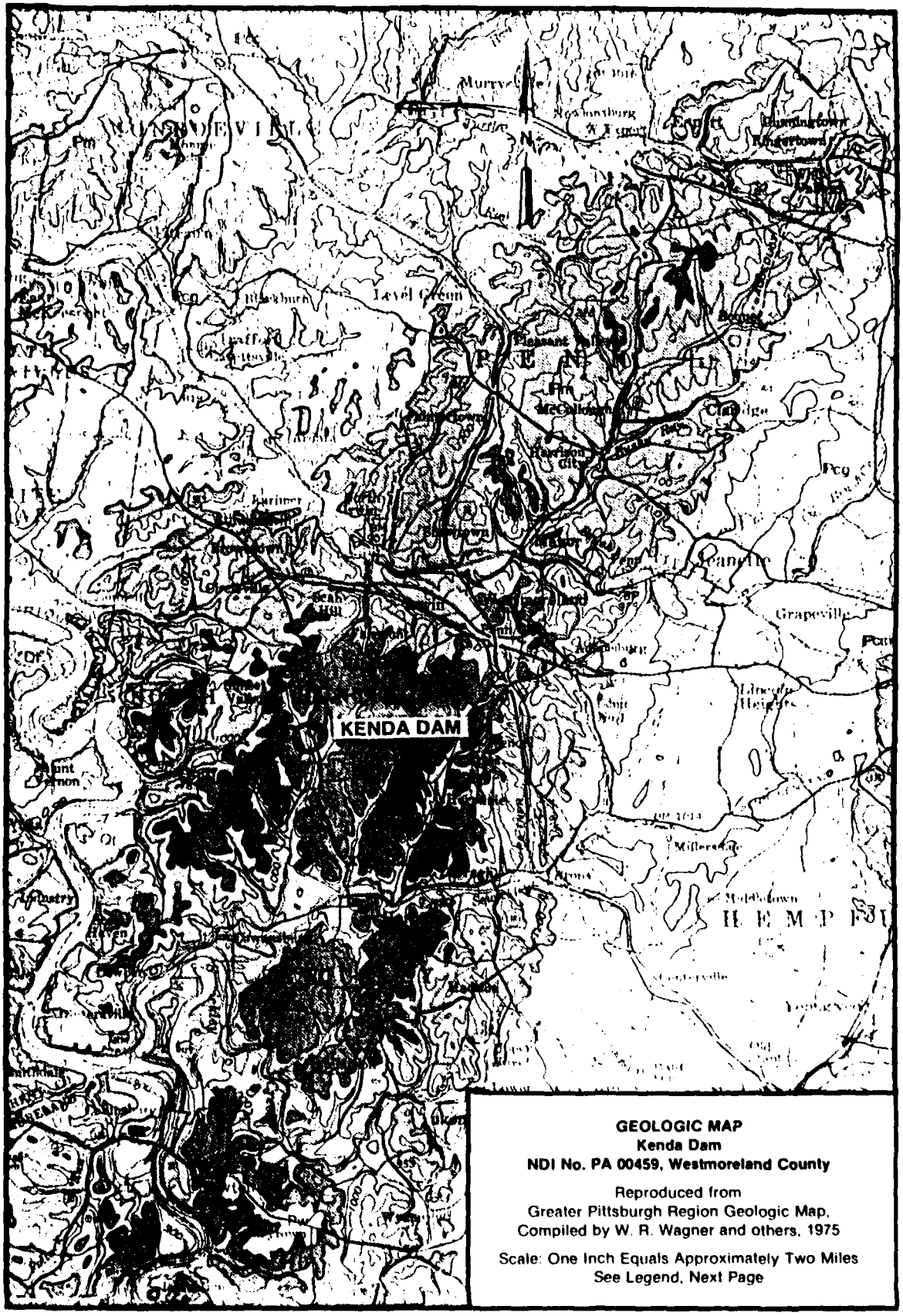
REGIONAL GEOLOGY

KENDA DAM
NDI No. PA 00459, PennDER No. 65-118

REGIONAL GEOLOGY

Kenda Dam is located in an unglaciated section of the Appalachian Plateaus Physiographic Province. Bedrock units below the dam are members of the Monongahela Group, Pennsylvanian System. These members consist of cyclic sequences of shale, limestone, sandstone, and coal. Bedrock units outcropping on the valley walls above the dam are members of the Waynesburg Formation, Dunkard Group, Pennsylvanian System. These members consist of cyclic sequences of sandstone, shale, limestone, and coal.

Located approximately 315 feet (Elevation 685 feet M.S.L.) beneath the dam site is the Pittsburgh coal which has been mined by the Westmoreland Coal Company's Marchard Mine (abandoned).



GEOLOGIC MAP
Kenda Dam
NDI No. PA 00459, Westmoreland County

Reproduced from
Greater Pittsburgh Region Geologic Map,
Compiled by W. R. Wagner and others, 1975

Scale: One Inch Equals Approximately Two Miles
See Legend, Next Page

GEOLOGY MAP LEGEND

GROUP	FORMATION		DESCRIPTION
	Alluvium	Qt	Sand, gravel, clay.
	Terrace deposits		Sand, clay, gravel on terraces above present rivers; includes Carmichaels Formation.
DUNKARD	Greene		Cyclic sequences of sandstone, shale, red beds, thin limestones and coals.
DUNKARD	Washington	Pw	Cyclic sequences of sandstone, shale, limestone, and coal; contains Washington coal bed at base.
DUNKARD	Waynesburg		Cyclic sequences of sandstone, shale, limestone and coal; contains Waynesburg coal bed at base.
MONONGAHELA		Pm	Cyclic sequences of shale, limestone, sandstone and coal; contains Pittsburgh coal bed at base.
CONEMAUGH	Casselman	Pcc	Cyclic sequence of sandstone, shale, red beds and thin limestone and coal.
CONEMAUGH	Ames		
CONEMAUGH	Glenshaw	Pcg	Cyclic sequences of sandstone, shale, red beds and thin limestone and coal; several fossiliferous limestone; Ames limestone bed at top.
ALLEGHENY	Vanport	Pa	Cyclic sequences of shale, sandstone, limestone, and coal; contains Brookville coal at base and Upper Freeport coal at top; within group are the commercial Vanport limestone and Kittanning and Clarion coals.
ALLEGHENY	Vanport	Pa	
POTTSVILLE		Pp	Sandstone and shale; contains some conglomerate and locally mineable coal.
Mauch Chunk		Mc	Red and green shale with some sandstone; contains Wymps Gap and Loyalhanna limestones.
Pocono			Sandstone and shale with Burgoon sandstone at top.


DATE
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